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SOCKEYE SMOLT POPULATION ESTIMATES, OUTMIGRATION TIMING, AND SIZE AT AGE CHARACTERISTICS FOR RED, AKALURA, AND FRAZER LAKES, 1994

By:
Charles O. Swanton
Bruce M. Barrett
and
Patricia A. Nelson

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INTRODUCTION

In the Kodiak Management Area (KMA; Figure 1), sockeye salmon *Oncorhynchus nerka* spawn in about 40 systems (Brennan et al. 1993). A number of these systems are within the Kodiak National Wildlife Refuge, 1.9 million acres set aside in 1941 to preserve brown bear habitat for feeding and reproduction. Sockeye salmon are an important food source for brown bear and an economic mainstay of the KMA commercial salmon fishery. The commercial fishery average harvest (1990-1993) of 4.9 million sockeye salmon has been worth about $ 29.3 million, annually (Brennan et al. 1993). The Kodiak salmon fleet consists of about 610 permit holders; 61% are Kodiak Island residents inclusive of six Native villages (K. Iverson, Alaska Department of Fish and Game, Commercial Fisheries Entry Commission, personal communication). The subsistence sockeye fishery is also important, averaging 19,000 fish annually (1988-1993; Brennan et al. 1993).

In 1989, crude oil spilled from the M/V Exxon Valdez in Prince William Sound entered the Gulf of Alaska, and subsequently contaminated all of the traditional KMA salmon harvest areas (Barrett and Monkiewicz 1989). As a consequence of curtailed fisheries, sockeye salmon escapement goals were exceeded at several systems during 1989, which included Afognak River, Akalura Creek, Dog Salmon River (Frazer Lake), and Ayakulik River (Red Lake).

The highest 1989 overescapements occurred at Red and Akalura Lakes. and there are concerns that sockeye productivity (e.g., the zooplankton community) in these systems may be damaged as a result. Previous studies have documented that excessive escapements tax rearing-limited systems by overloading the lake with too many juvenile sockeye salmon fry. This in turn results in alteration of the overall zooplankton biomass, species composition and sizes, thereby lowering sockeye survival (Kyle et al. 1988; Koenings and Kyle 1991). These changes can reduce over-winter sockeye fry survival, extend freshwater rearing for an additional year, and affect multiple brood years.

In 1990, sockeye salmon smolt studies were initiated at Red, Akalura, and Upper Station (control) Lakes to measure responses from the 1989 escapement event (Figure 2; Barrett et al. 1993). This report documents the fifth (1994) year of the study and includes the 1994 sockeye smolt work at Frazer Lake, conducted partially with oil spill funding. Frazer Lake was included in 1993 as an alternate control for the Akalura and Red Lakes damage assessment. The 1989 Frazer Lake escapement, however, enumerated at 360,373 fish, was 80% above the upper escapement goal of 200,000. Lake fertilization has occurred for five years (1988-1992), to correct for pre-1986 overescapements. Therefore, as a control it is not without problem.

OBJECTIVES

1. Estimate the number of sockeye smolts by age class for Red, Akalura, and Frazer Lakes.

2. Estimate sockeye smolt timing and growth characteristics (length, weight, and condition factor) by age class for each study lake.

3. Estimate the seasonal use of nearshore areas in Red Lake by young-of-year sockeye fry (age 0.).

METHODS

Smolt Traps and Site Locations

At Red Lake two Canadian fan traps (Ginetz 1977) were operated from 04 May through 27 June at a site located 1.6 km downstream of the lake outlet where water depth averaged 0.4 m and velocity generally exceeded of 0.9 m/sec. The traps were placed parallel to each other in the stream approximately 2 m and 6 m off the west bank. Both traps were equipped with perforated aluminum-plate leads (2.2 m each in length, 1 m width, 4.8 mm dia. holes) angled at 30° upstream. The two traps were connected together at the opening by an inverted V-shape structure fashioned from two pieces of perforated-plate lead. The nearshore trap was fitted with a single live box while the other had two live boxes (1.2 m long, 1.0 m wide, and 0.8 m high). The trap openings including the leads fished about 36% of the stream width.

At Akalura a single Canadian fan trap was operated from 04 May through 27 June, approximately 5.6 km downstream of the lake outlet. The trap was equipped with a live box measuring 1.5 m long, 1 m wide, and 0.8 m high. At the onset of operations, perforated-plate leads were attached to the trap opening extending 1.2 m to the west stream bank and 2.9 m to the east bank. The lead to the east was attached to the stream bank and effectively prohibited smolt passage. The leads (on 4 May) spanned approximately 31.4% of the stream width. On 4 May stream depth was 0.5 m and velocity about 0.9 m/sec. The west bank lead was extended 1.8 m on 15 May to increase trap catch, however trap catches remained static and it was removed the following day. Aluminum weir panels (1.8 m long covered with 6.5 mm square mesh hardware cloth) were used as leads and added to the initial west bank lead in increments of 1.8 m daily from 22-26 May. The length of the west bank lead on 26 May was 10.8 m which represented 66% of the streams width. On 27 May all west bank lead material except for the initial 1.8 m section was removed due to no appreciable increase in trap catch.

At Frazer Lake, an inclined plane trap as described by Todd (1994) was operated from 10 May through 28 June, approximately 1.2 km downstream of the lake outlet upstream of the falls and 76 m upstream of the diversion weir. The trap site was 12.7 m and 10.3 m from the east and west banks, respectively where water depth was 0.9 m and velocity 1.1 m/sec (measured on 12 May). Leads were attached to the trap angled about 30° and extended 3.9 m to both the east and west banks. The trap and leads spanned 17.4% of the stream width. Fishing a single inclined plane trap above the falls deviates from previous years when two traps were routinely fished below the falls (Barrett et al. 1993). The stream width at the site selected above the falls was where the stream was narrow and prohibits the use of two traps. Shields constructed of wood or aluminum were installed on the traps to reduce headlamp and lantern light in the trap entrances. All live boxes were covered with plastic fencing material to prevent predation.

Smolt Enumeration

At all locations traps were routinely checked during the evening approximately every half hour for catch and proper operation using artificial light sources (headlamps and gasoline lanterns). During daylight hours the traps were monitored less routinely. For each check the total catch was enumerated by species and released; an exception was when a portion of the catch was held for sampling (described in later section). Species identification was made by visual examination of external characteristics (McConnell and Snyder 1972; Trautman 1973).

Smolt enumeration was completed using direct visual counts; the exception was that a catch-weight method was implemented when catch rates exceeded the crew's ability (> 10,000 smolts) to hand tally. For this method, the catch was transferred by dip net to a small wetted mesh basket attached to a weight scale suspended over the stream by an A-frame support; each dip net load was individually weighed, with fish immediately released into the stream downstream of the traps. About every tenth dip net load was sampled to determine species count by weight. This entailed transferring a dip net load to a 19 L plastic bucket filled with water, counting the sample by species while spilling the catch into another 19 L bucket, and transfering the contents of the second bucket into the hanging basket for weighing. All catch weights were recorded to the nearest 0.1 kg.

All catch data were recorded by sampling day. A sampling day extended from noon to noon and was identified by the calendar day of the noon to midnight period.

Age, Weight, and Length Sampling

At each location, up to 70 sockeye smolt were sampled daily, five days a week, dependant upon smolt availablity, for age, length, and weight (AWL). To prevent bias all fish in the live-box were stirred immediately before being removed for sampling. Each sampled fish was anesthetized with MS-222 and a scale smear from the preferred area (INPFC 1963) was removed and mounted on a standard microscope slide for ageing. Smolt weight was recorded to the nearest 0.1 g using a Dial-A-Gram scale and tip-of-snout to fork-of-tail length (TL) was recorded to the nearest 1 mm. After sampling, all smolt were revived and released downstream of each trap site. Ageing of scales was conducted using a 42X lens microfiche reader. All ages were recorded in European notation (Koo 1962).

Trap Efficiency Tests

Trap efficiency was determined at least weekly dependant upon smolt availabilty. At all sites except Frazer Lake, approximately 500 smolt were dyed and released about 1 km upstream of the trap location in relatively low velocity water (<0.5 m/sec). At Frazer Lake, the number released was approximately 1,000 fish. Smolts used for trap efficiency tests were collected from the trap(s) within three days and often within one day of each test. An instream covered live box with perforated sides was used to hold the smolts prior to upstream transport. Transport was performed using backpacks and 19 L plastic buckets equipped with battery-powered aerators. At the release sites, smolts were placed into instream live boxes and held for about 30 minutes

before transfer into a continuously-oxygenated dye solution of 1.9 g Bismark Brown Y dye to 57 L of water for another 30 minutes. After dyeing, the smolt were held for about 60 minutes in an instream perforated live box with lid, and then placed in water filled 19 L buckets for release across the stream channel. At each step in the process, the smolt were counted, and those that behaved abnormally were destroyed. The dye test at each of the sites were scheduled so that the release time was about 2200 h. Following the release of dyed fish, the traps were checked for three or more days for recoveries. All recaptures were recorded separately from the unmarked fish catch and were not included in the daily trap catch totals.

Climate Observations

At the smolt trap locations of all three lakes, air and stream temperatures (C), stream height (cm), percent cloud cover, wind velocity, and wind direction were recorded at about 1800 h daily.

Littoral Zone Seining

At Red Lake, four shoal sites originally selected in 1992, were sampled weekly (May through at least June) using a beach seine measuring 15 m in length, 2 m deep, and about 6 mm stretch mesh. The catch was counted and recorded by species with TL (mm) recorded for sockeye salmon only. Water temperature (C) was taken during each sampling event.

Townet Surveys

Townet surveys of oil spill study lakes have been conducted during 21 September-6 October annually since 1990 for indexing rearing fry abundance and size characteristics. Fish species composition is used in conjunction with fall hydroacoustic surveys to estimate fry populations. Surveys at Red, Upper Station, and Akalura Lakes were conducted using an 4.9 m rubber raft and 30 hp outboard motor operated at full rpm; at Frazer Lake a 5 m Boston whaler with 40 hp motor is used. The townet measured 2 m x 2 m at the entrance and 7.5 m in length. The body of the net was constructed of variable mesh (3.8 cm, 1.3 cm, and 0.6 cm) knotless nylon and the cod end of the net was 0.5 m long with 0.3 cm mesh and a zipper for removal of the catch. Plastic floats were attached to the top of the net entrance and a 3.8 cm diameter steel bar lashed to the bottom. Tow lines (1.27 cm polypropyline) used for the net were 91.5 m long, allowing for consistent fishing at 9.1 m depth which is where from previous hydroacoustic surveys a majority of the sockeye fry were located.

Each syrvey consisted of three 20 to 35 minute tows along preselected transects for each lake. Catch from each tow was sorted, counted, and recorded by species, except when greater than 200 stickleback *Gasterosteus aculeatus* were captured for a single tow. In these situations, a random grab sample of 100-150 stickleback were counted, weighed, and total catch numbers estimated using the catch-weight method previously described.

Townet surveys have been conducted at Frazer Lake since 1985, and at Red, Upper Station (Upper Olga Lake), and Akalura Lakes from 1990-1991. In 1992, only Red and Upper Station

Lakes were surveyed. Akalura Lake was dropped from the survey program due to low catches of sockeye relative to sticklebacks, and the lack of data utility related to accompanying hydroacoustic studies. During 1993 Frazer Lake was designated as the control lake, therefore Upper Station Lake townet data are not presented. For ease of comparison we report the data collected since 1990.

DATA ANALYSIS

The estimation of smolt numbers from the catch-weight method (when employed) the following relationship was used:

$$\hat{C}=\frac{ac}{b}, \qquad (1)$$

where a is the grand smolt weight total less basket weight; b is a subsample of total weight less basket weight; and $\hat{C}$ is the count of smolt from subsampled baskets.

In deriving trap efficiency from the mark-recapture and trap catch data the formula used was:

$$\hat{e}=\sum_{i=1}^{k}\frac{d_i}{D_i} \qquad (2)$$

where d_i is the number of marked fish recaptured over (k) successive nights after release, and D_i is the number of marked fish released on day i. Since mark-recapture trap efficiencies were estimated on a weekly basis, we tested for heterogeneity between events and the pooled seasonal trap efficiency for all systems employing a chi-square test at α=0.05 (Zar 1984). For both Red and Akalura Lakes significant homogeniety test statistics were generated (df=5 and 4 respectively, $p<0.01$). Therefore, we employed linear interpolation between weekly trap efficiency values to estimate daily trap efficiency for these systems. For estimates prior to the first and after the last mark-recapture events we used the first and last trap efficiency estimates for these days. A nonsignificant homogeniety test statistic was found for Frazer Lake (df=6, $p<0.25$); a seasonal pooled trap efficiency estimate was employed for this system. Rawson (1984) reported statistical models for treating sockeye smolt mark-recapture data derived on a daily basis with population estimates generated by:

$$\hat{N}_i=n_i\left[\frac{D_i}{d_i}+\frac{(D_i-d_i)}{d_i^2}\right];$$

with variance

$$Var\left[\hat{N}_i\right]=n_i(n_i+d_i)\ D_i(D_i-d_i)/d_i^3.$$

The overall annual smolt outmigration for a particular system was estimated by:

$$\hat{N}=\sum_{i=1}^{k}\hat{N}_i; \tag{3}$$

with the overall variance estimated by:

$$Var[\hat{N}]=\sum_{i=1}^{k}Var[\hat{N}_i] \tag{4}$$

where:

i) N_i= Total population of smolt outmigrating on day i;
ii) n_i= Number of unmarked fish captured in traps during day i;
iii) N = Total smolt population outmigrating over k days.

The (1-α) confidence intervals for the smolt population estimates were derived assuming a normal distribution (Rawson 1984).

Condition factor for each smolt sampled was determined using:

$$K=\frac{W*10^5}{L^3} \tag{5}$$

where W = weight in grams and L = length (tip-of-snout to fork-of-tail) in millimeters.

RESULTS

The 1994 daily sockeye smolt trap catch numbers and trap efficiency estimates for Red, Akalura, and Frazer Lakes are provided in Appendix A. Daily smolt population estimates and associated 95% confidence intervals are listed in Appendix B. Population estimates stratified by week and age class are provided in Appendix C. Smolt length, weight, and condition factor by age class and statistical week for each lake are summarized in Appendix D. Red Lake littoral zone seine catches for 1992-1994 are presented in Appendix E. Tow net survey catches and sockeye salmon fry length, weight, and age statistics from Red, Akalura, and Frazer Lakes for 1990-1994 are reported in Appendix F. The 1994 climatological data by system and day are reported in Appendix G. A map of the Red Lake beach seining sites is provided in Appendix H. Preseason 1995 sockeye run forecasts for Red and Frazer Lakes are reported in Appendix I.

Red Lake

The smolt traps were operational on 4 May and ceased operation on 27 June, during which time a total of 122,607 smolt were caught (Appendix A.1). There were 3,277 smolt marked, 60,831 fish examined for marks, and 673 marked smolt recovered for a 20.5% seasonal recapture rate. During 1994, 562,690 smolt (95% CI = 472,305 to 647,655) were estimated to have emigrated from Red Lake (Appendix B.1). The 1994 smolt outmigration was 21,000 less than in 1993 and about 25% less than the 1990-1992 average (Table 1; Figure 3). Age-2. smolt from the 1991 brood year (BR) were most abundant contributing 92% to the total, followed by age-1. smolt at 7% (1992 BR). Age-3. smolt contributed less than 1% (1990 BR; Figure 3). While fewer smolts outmigrated in 1994, a major shift to age-2. smolts from that experienced during 1993 was evident. The only year having a similar percentage of age-2. smolts was 1992.

Ages-1. and -2. smolts emigration timing during 1994 were similar, both reaching peak abundance during 31 May through 6 June (Figure 4; Appendix C.1). Age-2. smolt emigrated about one week later than during 1993, whereas age-1. smolt emigration timing was similar to 1993.

Both the mean length and weight of age-1. and -2. smolts in 1994 decreased compared to 1992 and 1993 with weights declining > 30%. Only sockeye smolt weights measured in 1991 were comparable (Tables 7; Figure 5).

Age-0. sockeye fry found rearing in the littoral areas of Red Lake occurred earlier in 1994 than either 1992 or 1993 (Figure 6; Appendix E.1). Peak catches in 1994 and 1993 occurred in late May, while in 1992 the peak occurred in mid-June. Littoral zone rearing fry numbers observed during 1994 were about 2.2 times higher than in 1993 and about 3 times higher than in 1992. Conversely, stickleback numbers were substantially less than those observed during 1993. For the years 1992-1994 a majority of sockeye fry and stickleback were found at site four near the northwest end of Red Lake (Appendix E.1; H.1). It is likely that the number of sockeye fry caught at this site were affected by close proximity to Connecticut Creek, the major sockeye spawning tributary. In all years, sockeye fry in the littoral zone averaged about 35 mm in length during May and June (Appendix E.3).

Sockeye salmon rearing fry relative abundance as indexed from fall townet catches were similar to those from 1991 and show a marked increase over those observed from 1992 and 1993. Catch per unit effort (CPUE) of sockeye fry in 1994 was higher than from the previous two years (Appendix F.1). The relative abundance of stickleback observed in 1994 was similar to 1990-1991, lower than 1992 but greater than in 1993. Stickleback comprised 95.7% of the total catch with CPUE being above the 1990-1993 average.

Akalura Lake

The trap at Akalura Lake was installed on 4 May and operated through 27 June. A total of 26,726 sockeye smolts were captured of which 2,021 were marked. A total of 16,227 smolts were examined for marks and 272 marked fish recaputured over the season for an overall trap efficiency of 13.4%. Trap efficiecies over the season ranged from 5.8% to 19.1% (Appendix A.2). The 1994 smolt outmigration was an estimated 170,172 smolts (95% CI 130,910 to 209,433) about a two fold increase over 1993 but below the 1990-1992 average of 325,972 (Table 3). Age-2. smolts were the most abundant comprising 53% (1991 BR) of the total, followed by age-1. at 42% (1992 BR), and age-3. at 4% (1990 BR; Table 4; Figure 7; and Appendix C.2). Age-3. smolts were less abundant than in both the 1992 and 1993 outmigrations.

The peak of the age-2. emigration in 1994 occurred in late May, approximately two weeks later than in 1990-1992, and about one week later than in 1993. For age-1. smolts, peak outmigration timing occurred in early June (Figure 8; Appendix C.2).

All age classes of smolts were of larger mean size in 1994 than during 1990-1993 (Table 7; Figure 9). Age-1. smolts averaged about 15 mm larger and weighed 2.9 g more than age-1. smolts from 1990-1993, while age-2. smolts were 11 mm larger and 2.6 g greater in weight than smolts from 1990-1993.

Frazer Lake

At Frazer Lake, a single inclined plane trap was operated from 10 May through 28 June (Appendix A.3). A total of 301,160 sockeye smolts were caught in the trap and 6,822 were marked. Over the season, a total of 126,484 smolts were examined for marks and 349 were recovered for a seasonal trap efficiency estimate of 5.1%. Estimated trap efficiencies ranged from 3.4% to 6.2% over the season. The total sockeye smolt outmigration was an estimated 5.9 million smolts (95% CI = 5,285,225 to 6,520,501; Appendix B.3), which was about 0.4 million less than the 1991-1993 outmigrations (Tables 5 and 6). Age-2. (78%) smolt dominated the outmigration compared to age-1. (12%) smolt. In comparison, the 1991 age-1. (40%) and -2. (59%) smolt represented most of the estimate, whereas in 1993 the smolt age composition was evenly divided between ages-2. and -3. (Figure 10).

The 1994 smolt migration peaked from 14-20 June for age-1. smolts and 24-30 May for ages-2. and 3. smolts (Figure 11).

In 1994, age-1. smolts averaged about 86 mm which was slightly less than the 1990-1993 average of 87.5 mm (Tables 7; Figure 12). Ages-2. and -3. smolt were slightly larger than in 1993. The mean weight of age-1. smolts was similar to those of 1990-1993 average while age-2. and -3. smolts were larger than average.

The 1994 townet survey catches show markedly fewer rearing sockeye fry in 1994 than in surveys conducted during 1990-1993 (Appendix F.3). A total of two fry were caught during 1994 which may inpart have been due to poor survey conditions. The only other year which had similar number was during 1993 when 16 fry were caught. Stickleback catches in 1994 were two fold greater than during 1993 but similar to 1992.

DISCUSSION

Red Lake

The 1994 Red Lake smolt outmigration completes the 1990 BR. An estimated 0.2 million sockeye smolts were produced from the 0.37 million 1990 escapement. This represents about 7 times fewer smolts than estimated for the 1989 BR and 1.7 times less than for the 1988 BR. Smolt population estimates for the 1987 and 1988 brood years should be considered relative indices, as the population estimates for these years is marginal. The lack of confidence in these estimates is based upon age 2. smolt numbers which we adjusted using a 30% smolt to adult survival rate (Koenings et al. 1993) that were 4.5 times lower than the number of age 2. adult returns. We believe error in this estimate is centered around using a single smolt trap during 1990 that experienced substantial avoidance by age 2. smolts. Although two traps were used during 1991, trap avoidance still appeared to be a problem. Age 1. and 2. smolt estimates after adusting for marine survival were 2.0 and 4.3 times lower, repectively than the numbers of freshwater age 1. and 2. returning adults. During 1992, trap configuration was modified, a smolt weir operated, and resulting smolt population estimates evaluated (Barrett et al. 1993).

It appears based upon sockeye smolt numbers for the 1990 brood year that the adult return from this brood year will be a failure. Assuming 30% ocean survival (mean length 108.6 mm) the 193,000 age-2. smolts from the 1990 BR will result in only about 58,000 age 2.2 adults, and the return of age-1. and 3. adults will be negligable. The smolt sizes from the 1990-1991 BR's suggest that experiencing greater than 30% smolt-to-adult survival from these BR's is not anticipated.

The robust index of rearing fry numbers observed in 1994 promotes optimism that 1995 and 1996 smolt outmigrations will improve over the previous two years. We observed no apparent differences in the age-0. rearing fry length between years or within a year; however, rearing fry generally begin pelagic rearing at 35-40 mm in length (Barrett 1989). Therefore, fry lengths are probably a biased index of littoral zone rearing conditions. In addition, this premise is supported by ther relatively static fry length observed.

An adult preseason run forecast of 425,000 fish was derived for 1994. Most of the run (70%) was projected to be age-2.2 sockeye from the 1989 escapement of 0.8 million adults. The actual run was an estimated 423,861 sockeye salmon comprised of a 380,181 fish escapement and 43,680 fish commercial catch. The difference represents less than a 1% forecast error. The 1995 preseason run forecast is for 325,000 fish, which if accurate, will allow for only minimal fishing time (if any) within the terminal fishing area in order to meet the escapement goal of 200,000-

300,000 (Appendix I.1). The 1995 run is projected to be about 35% 2-ocean age fish (1990 BR) and 60% 3-ocean age fish (1989 BR).

Akalura Lake

Based on 1990-94 smolt outmigrant estimates, the 1987, 1988 and 1989 BR's produced about twice the number of smolt as the 1990 and 1991 BR's. Overall, Akalura Lake has shown a steady decline in smolt production and a shift in age composition to fewer age-1. smolts and more age-3. smolts. However, age-2. smolts have remained dominant.

In 1994, Akalura Lake recieved an escapement of 13,381 fish for both the early and late runs combined. This level of escapement was well below the minimum escapement goal of 40,000. The 1995 sockeye run is not expected to meet minimum escapement requirements based upon smolt numbers produced from the 1989 and 1990 BR's. We suspect that the 1995 run will be lower than that experienced in 1994. No commercial fishing time should be expected within the Inner and Outer Akalura Sections (ADF&G 1993) in 1995.

Frazer Lake

Based on the 1991-1993 outmigrant smolt estimates, the 1989 BR produced an estimated 12.9 million smolts from an escapement of 0.36 million adults. The 1988 (incomplete), 1990, and 1991 BR's have produced roughly 50% fewer smolts, when the attendant escapement levels were about 20% less than in 1989. The 1991 BR had a discouraging response in terms of age-1. smolt production (0.1 million); however there were 4.6 million age-2. smolts that emigrated during 1994. Overall, age-1. smolt production has dramatically decreased (1989-1991 BR's), whereas age-2. smolt numbers appear to be relatively stable (1989-1991). Age-3. abundance has increased markedly (1987-1989) but begining with the 1990 BR appear to be on the decline.

The 1995 preseason Frazer Lake sockeye forecast is 725,000 fish (Appendix I.2) which is similar that of 1994. The 1995 run is projected to be comprised of 39% age 2.2 (1990 BR) and 30% age-3.2 fish (215,000 fish; 1989 BR). The actual return of age-3.2 fish could be substantially higher than forecast owing to there being 4.6 million age 3. smolts that emigrated during 1993.

LITERATURE CITED

ADF&G (Alaska Department of Fish and Game). 1993. 1993 Cook Inlet/Kodiak/Chignik Commercial Fishing Regulations, Alaska Department of Fish and Game, Divison of Commercial Fisheries Management and Development, Juneau.

Barrett, B.M. 1989. Frazer Lake sockeye salmon investigations, 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fisheries Report 89-03, Juneau.

Barrett, B. M., and B.E. Monkiewicz 1989. A survey of the Kodiak Management Area salmon fishing grounds for oil spill contaminants, 16 April to 17 September, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K89-25, Kodiak.

Barrett, B. M., P.A. Roche, and C.O. Swanton. 1993. Sockeye salmon *Oncorhynchus nerka* smolt investigations at Red, Akalura, and Upper Station Lakes conducted in responce to the 1989 M/V EXXON VALDEZ oil spill, 1990-1992. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K93-01, Kodiak.

Brennan, K., D. Prokopowich, and D. Gretsch. 1993. Kodiak Management Area commercial salmon annual management report, 1992. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 4K93-28, Kodiak.

Ginetz, R.M.J. 1977. A review of the Babine Lake development project 1961-1976. Environment Canada. Fish and Marine Serv. Tech. Rept. Serv. No. Pac-T-77-6, 192p.

INPFC (International North Pacific Fisheries Commission). 1963. Annual Report 1961. Vancouver, British Columbia.

Koenings, J.P., and G.B. Kyle. 1991. Collapsed populations and delayed recovery of zooplankton in response to heavy juvenile sockeye salmon (*Oncorhynchus nerka*) foraging. (Proceedings: International Symposium on Biological Interactions of Enhanced and Wild Salmonids held at Nanaimo, B.C., Canada). Spec. Publ. Can J. Fish. and Aquat. Sci. In Review.

Koenings, J.P., Geiger, H.J., and Hasbrouck J.J. 1993. Smolt-to-adult survival patterns of sockeye salmon (Oncorhynchus nerka): Effects of smolt lenght and geographic latitude when entering the sea. Can. J. Fish. Aquat. Sci. 50: 600-611.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37-48. In: Studies of Alaska red salmon. University of Washington Press, Seattle.

LITERATURE CITED (Cont.)

Kyle, G.B., Koenings, J.P., and Barrett, B.M. 1988. Density dependent trophic level responses to an introduced run of sockeye salmon (*Oncorhynchus nerka*) at Frazer Lake, Kodiak Island, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 45:856-867.

McConnell, R.J., and Snyder, G.R. 1972. Key to field identification of anadromous juvenile salmonids in the Pacific Northwest. National Oceanic and Atmospheric Administration Technical Report National Marine Fisheries Service Circular 366, Seattle.

Rawson, K. 1984. An estimate of the size of a migrating population of juvenile salmon using an index of trap efficiency obtained by dye marking. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development Report 28, Juneau.

Todd, G. L. 1994 A lightweight inclinded -plane trap for sampling salmon smolt in rivers. Alaska Department of Fish and Game. Alaska Fishery Research Bulletin 1 (2):179-186.

Trautman, M.B. 1973. A guide to the collection and identification of presmolt Pacific salmon in Alaska with an illustrated key. National Oceanic and Atmospheric Administration Technical Memorandum National Marine Fisheries Services ABFL-2, Seattle.

Zar, H.J. 1984. Biostatistical Analysis. Second ed. Prentice-Hall, Inc., Englewood Cliffs, N.J.

Table 1. Red Lake sockeye salmon smolt population estimates by year and age, 1990-1994.

Smolt Outmigration Year	Number and Relative Percentages of Smolt by Age Class				95% CI	
	1.	2.	3.	No. Smolt	Low	High
1990	240,500 32.5	493,026 66.6	6,427	739,953	402,905	1,077,004
1991	105,467 40.0	119,849 45.5	38,184 14.5	263,500	178,221	348,782
1992	29,482 2.1	1,365,082 96.1	25,792 1.8	1,420,356	1,117,748	1,722,965
1993	303,462 52.0	193,884 33.2	86,644 14.8	583,990	436,166	731,804
1994	40,404 7.2	520,391 92.5	1,895 0.3	562,690	472,305	647,655

Table 2. Red Lake sockeye salmon escapement and smolt production by brood year, 1986-1994.

Brood Year	Escapement	Smolt Numbers by Age (and Percent)			Total
		1.	2.	3.	
1986	318,135	[a]	[a]	6,427	6,427[b]
1987	261,913	[a]	493,026	38,184	531,210[b]
1988	291,774	240,500 (62.3)	119,849 (31.0)	25,792 (6.7)	386,141
1989	768,101	105,467 (6.8)	1,365,082 (87.7)	86,642 (5.5)	1,557,191
1990	371,282	29,482 (13.1)	193,882 (86.1)	1,895 (0.8)	225,259
1991	374,859	303,462	520,391	[c]	823,853[b]
1992	344,184	40,404	[c]	[c]	40,404[b]
1993	286,170	[c]	[c]	[c]	
1994	380,181				

[a]Smolt outmigration not monitored
[b]Incomplete brood year data.
[c]Smolt of this age class have not outmigrated.

Table 3. Akalura Lake sockeye salmon smolt population estimates by year and age, 1990-1994.

Smolt Outmigration Year	Number and Relative Percentages of Smolt by Age Class 1.	2.	3.	4.	No. Smolt	95% CI Low	High
1990	66,460 14.0	408,330 86.0	0 0.0	0 0.0	474,790	318,734	630,846
1991	9,086 2.9	299,591 96.7	1,251 0.04	0 0.0	309,928	237,981	381,875
1992	1,921 2.9	182,963 96.7	8,315 4.3	0 0.0	193,199	153,765	232,638
1993	3,259 3.7	73,062 82.3	12,315 13.9	238 0.1	88,874	35,943	141,802
1994	72,474 42.6	90,467 53.2	7,141 4.2	0 0.0	170,172[a]	130,910	209,433

[a] An estimated 90 age 0. smolt outmigrated in 1994.

Table 4. Akalura Lake sockeye salmon escapement and smolt production by brood year, 1986-1994.

Brood Year	Escapement	Smolt Numbers by Age (and Percent) 1.	2.	3.	4.	Total
1986	9,800	[a]	[a]	0	0	[a]
1987	6,116	[a]	408,330	1,251	0	409,581[b]
1988	38,618	66,460 (17.7)	299,591 (80.0)	8,315 (2.2)	238 (0.1)	374,604
1989	116,029	9,086 (4.4)	182,963 (89.5)	12,315 (6.0)	0	204,364
1990	47,181	1,921 (2.3)	73,062 (89.0)	7,141 (8.7)	[c]	82,124[b]
1991	44,189	3,259	90,467	[c]	[c]	93,726[b]
1992	63,269	72,474	[c]			72,474
1993	30,692	[c]	[c]	[c]	[c]	
1994	13,381					

[a] Smolt migration not monitored.
[b] Incomplete brood year data.
[c] Smolt of this age class have not outmigrated.

Table 5. Frazer Lake sockeye salmon smolt population estimates by year and age, 1991-1994.

Smolt Outmigration Year	Number and Relative Percentages of Smolt by Age Class				95% CI		
	1.	2.	3.	4.	No. Smolt	Low	High
1991	2,552,835	3,777,426	3,786	0	6,334,047	2,128,460	10,539,634
	40.3	59.6	0.1	0.0			
1992	108,489	5,739,150	557,584	0	6,405,223	2,649,678	10,160,766
	1.7	89.6	8.7	0.0			
1993	23,496	5,077,865	4,687,084	612	9,789,057	3,309,885	16,268,229
	0.2	51.9	47.9	0.0			
1994	727,781	4,608,258	566,824	0	5,902,863	5,285,225	6,520,501
	12.3	78.1	9.6	0.0			

Table 6. Frazer Lake sockeye salmon escapement and smolt production by brood year, 1986-1994.

Brood Year	Escapement	Smolt Numbers by Age (and Percent)				Total
		1.	2.	3.	4.	
1986	126,529	[a]	[a]	[a]	0	[b]
1987	40,544	[a]	[a]	3,786	0	3,786[b]
1988	246,704	[a]	3,777,426	557,584	612	4,335,622[b]
1989	360,373	2,552,835 (19.7)	5,739,150 (44.2)	4,687,083 (36.1)	0	12,979,068
1990	226,960	108,489 (1.9)	5,077,866 (88.3)	566,824 (9.8)	[c]	5,753,179
1991	190,358	23,496	4,608,258	[c]	[c]	4,631,754
1992	185,825	727,781	[c]	[c]	[c]	727,781[b]
1993	178,391	[c]	[c]	[c]	[c]	
1994	206,071					

[a] Population estimates not currently available
[b] Incomplete brood year data.
[c] Smolt of this age class have not outmigrated.

Table 7. Mean smolt length and weight by system, age, and year, 1990-1994.

System	Smolt Year	Age-0. N	Age-0. Length (mm)	Age-0. Weight (g)	Age-1. N	Age-1. Length (mm)	Age-1. Weight (g)	Age-2. N	Age-2. Length (mm)	Age-2. Weight (g)	Age-3. N	Age-3. Length (mm)	Age-3. Weight (g)	Age-4.0 N	Age-4.0 Length (mm)	Age-4.0 Weight (g)
Red Lake																
	1990	0			342	106.5	10.0	1,052	111.8	11.0	20	117.9	13.0	0		
	1991	0			1,135	88.2	5.0	977	106.7	9.5	407	113.0	11.3	0		
	1992	0			85	99.5	8.8	1,667	110.2	11.8	63	119.7	15.2	0		
	1993	0			1,409	91.7	7.3	516	108.6	11.0	397	120.1	14.5	0		
	1994	0			225	86.2	5.1	1,718	98.7	7.6	7	104.9	9.0	0		
Akalura Lake																
	1990	0			577	73.9	3.6	749	85.9	5.3	0			0		
	1991	0			41	77.2	4.3	1,382	77.5	4.0	22	97.3	8.9	0		
	1992	1	59.0	1.5	25	75.7	3.7	2,014	78.8	3.9	61	86.4	4.9	0		
	1993	0			74	61.8	1.2	992	85.8	5.7	94	90.8	6.8	2	101.5	2.5
	1994	2	73.0	3.4	721	87.5	6.1	763	93.1	7.3	146	95.8	7.7	0		
Frazer Lake																
	1990	0			574	84.2	4.5	553	104.3	9.0	44	113.0	12.2	0		
	1991	0			746	89.7	5.4	1,344	89.5	5.6	4	120.8	15.7	0		
	1992	0			49	86.4	6.1	2,951	83.9	5.5	191	91.1	7.2	0		
	1993	0			8	89.9	6.1	682	100.3	8.3	913	104.2	9.2	3	121.3	9.4
	1994	0			713	86.3	5.2	1,456	102.6	8.1	302	112.8	10.7	0		

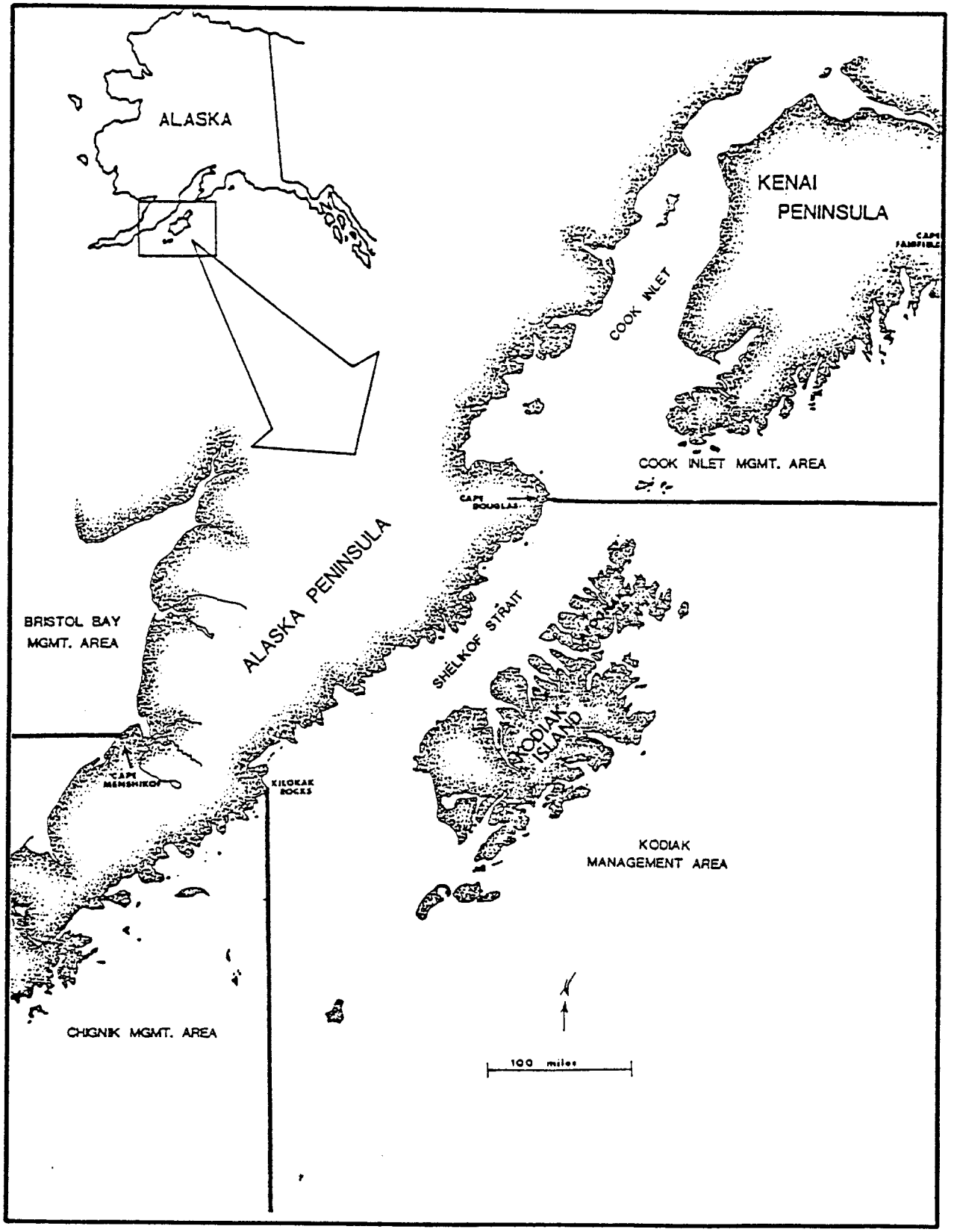

Figure 1. Map depicting Kodiak and adjacent salmon management areas.

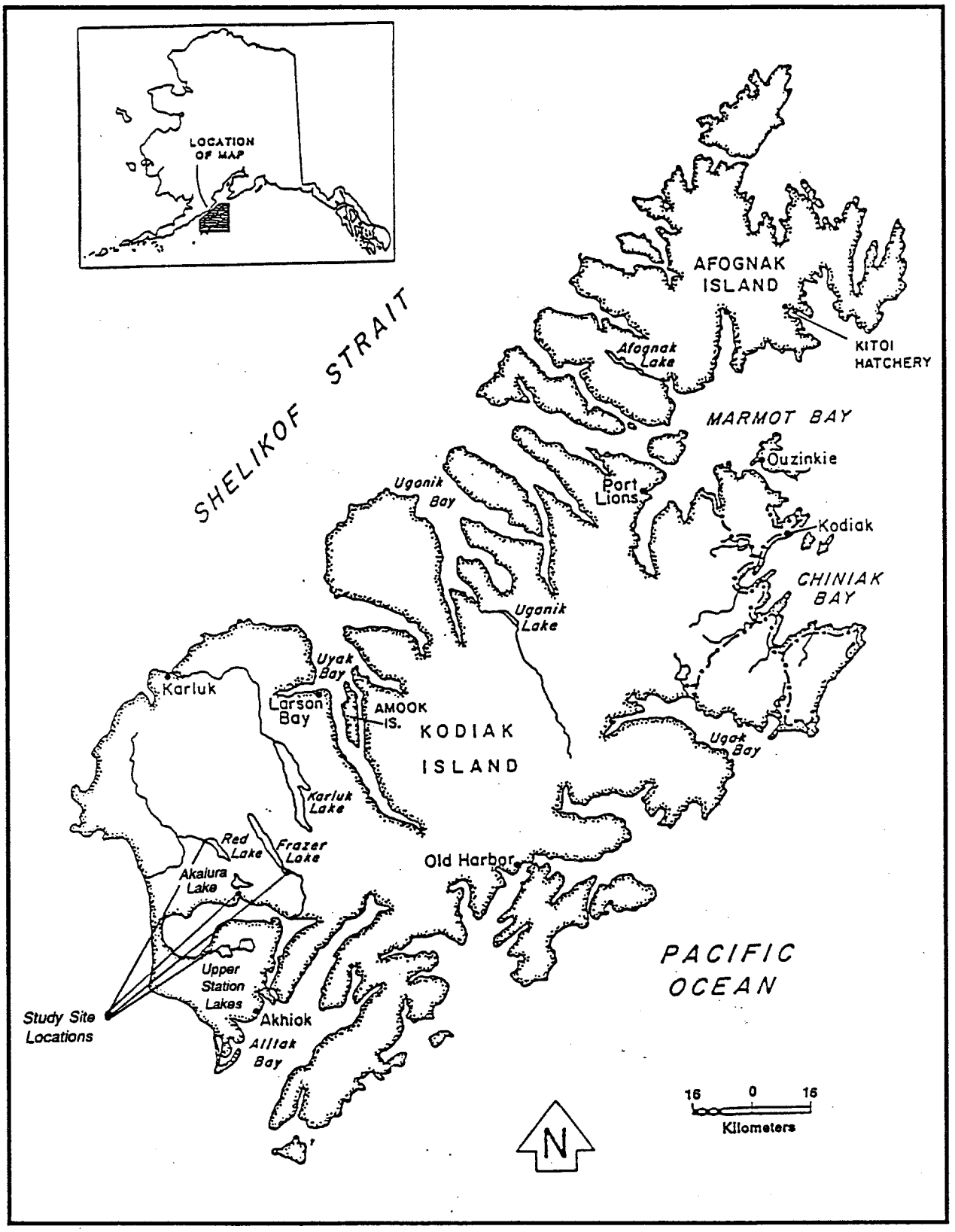

Figure 2. Map depicting locations of sockeye salmon smolt study sites at Red, Akalura, and Frazer Lakes, Kodiak Island, Alaska.

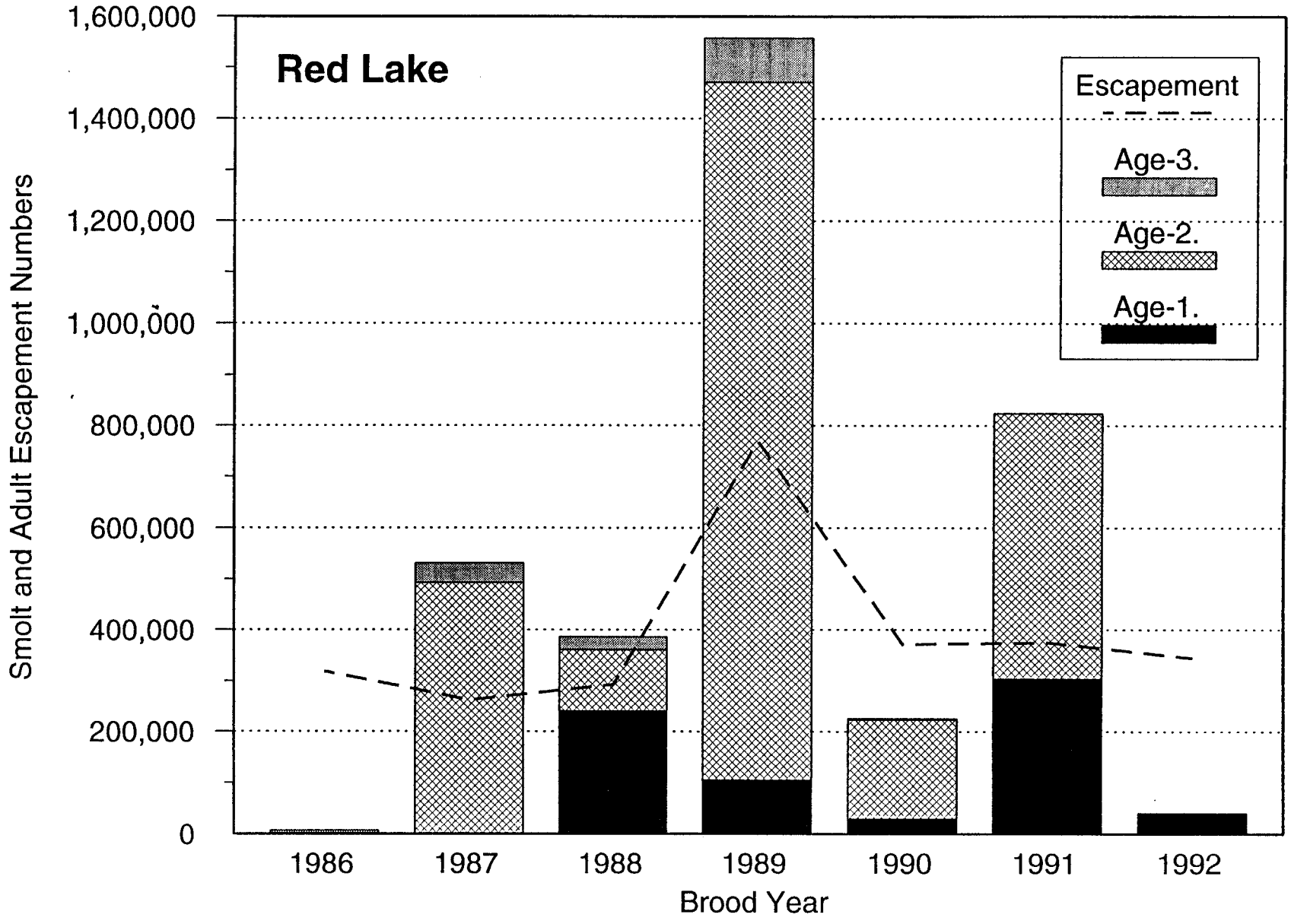

Figure 3. Sockeye salmon escapement and smolt production by age and brood year, Red Lake, 1986 - 1992.

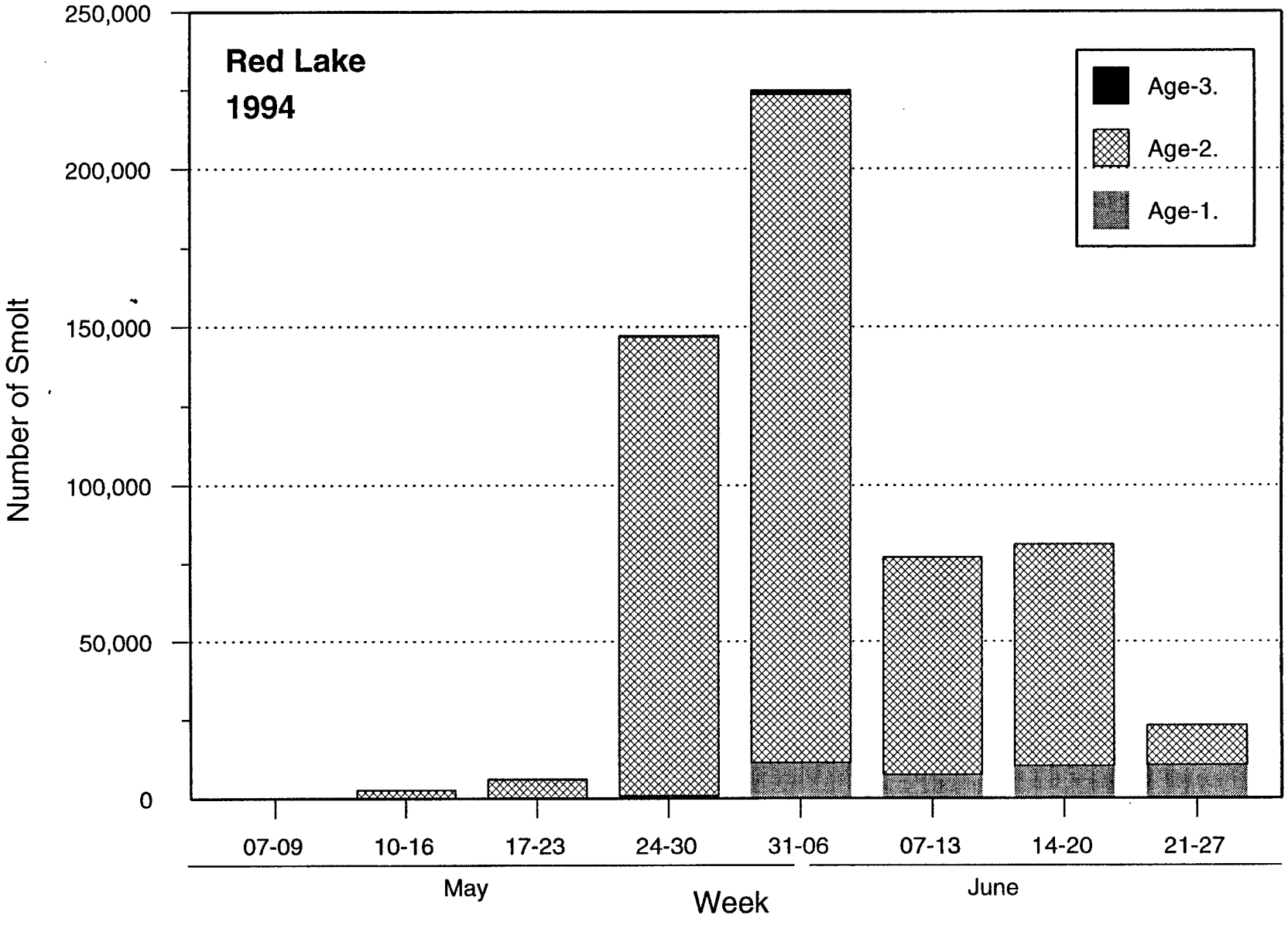

Figure 4. Sockeye salmon smolt outmigration timing by age, Red Lake, 1994.

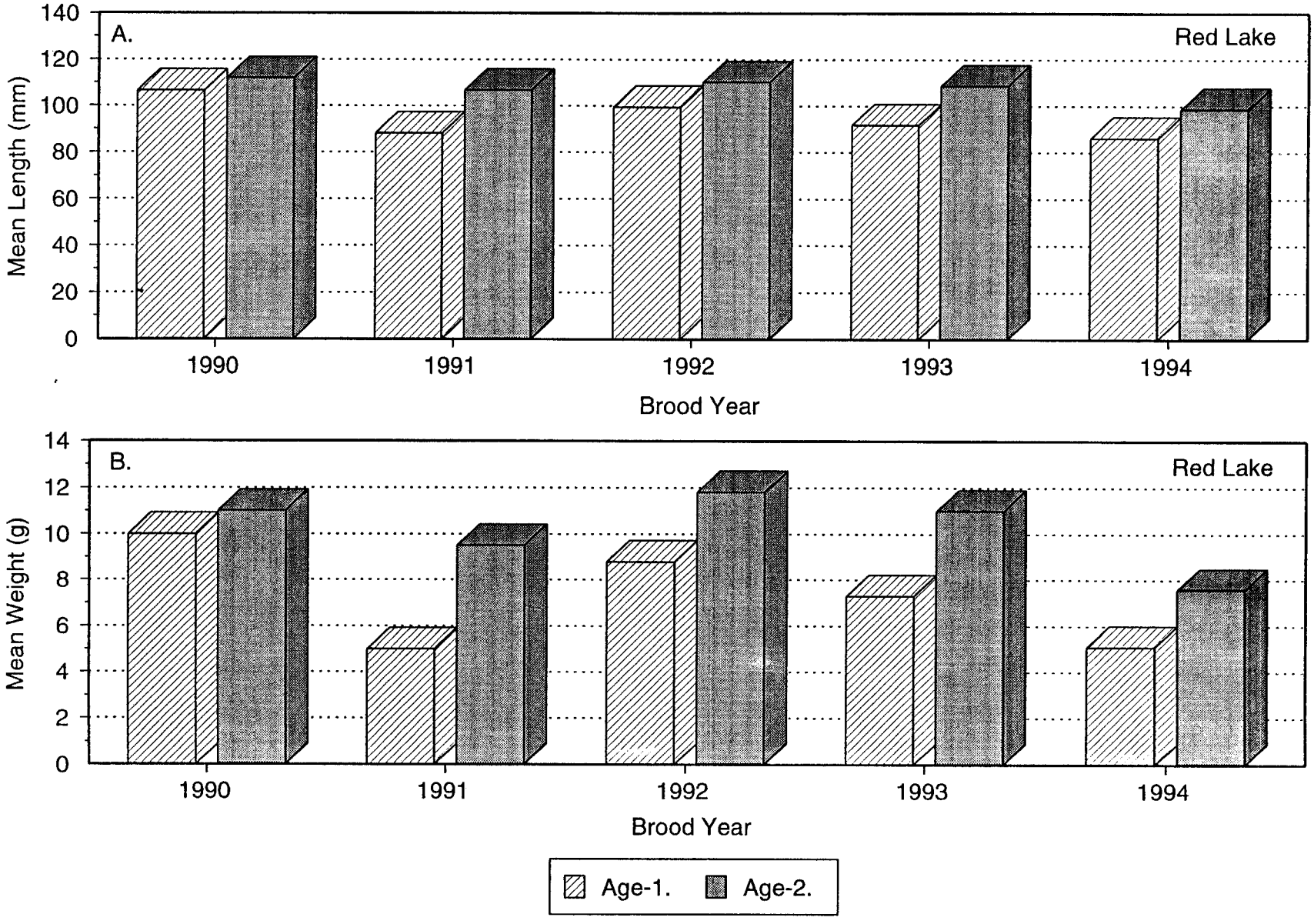

Figure 5. Red Lake mean smolt length (A) and weight (B) by year and age, 1990-1994.

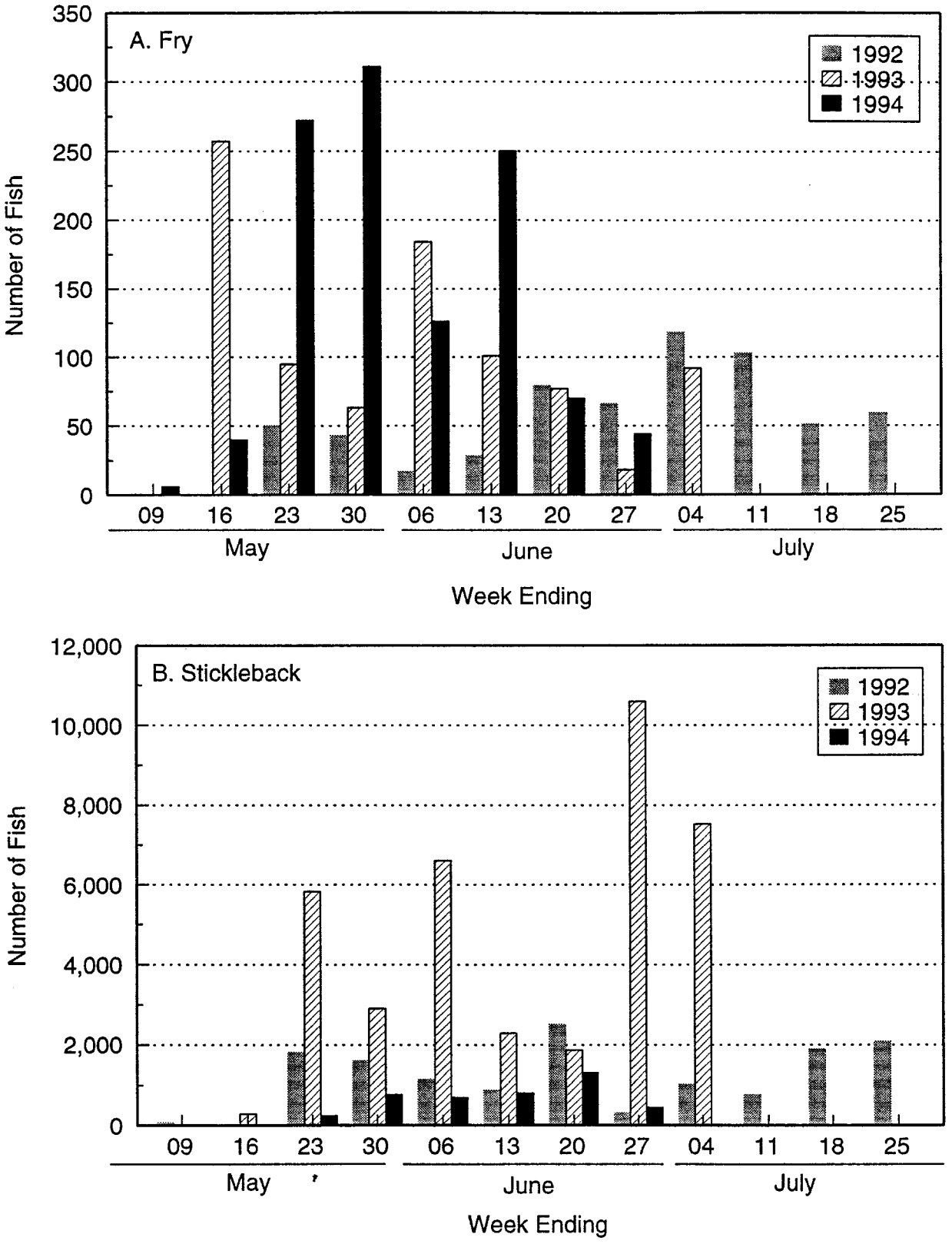

Figure 6. Sockeye salmon fry (A) and stickleback (B) littoral zone seine catch by week, Red Lake, 1992-1994.

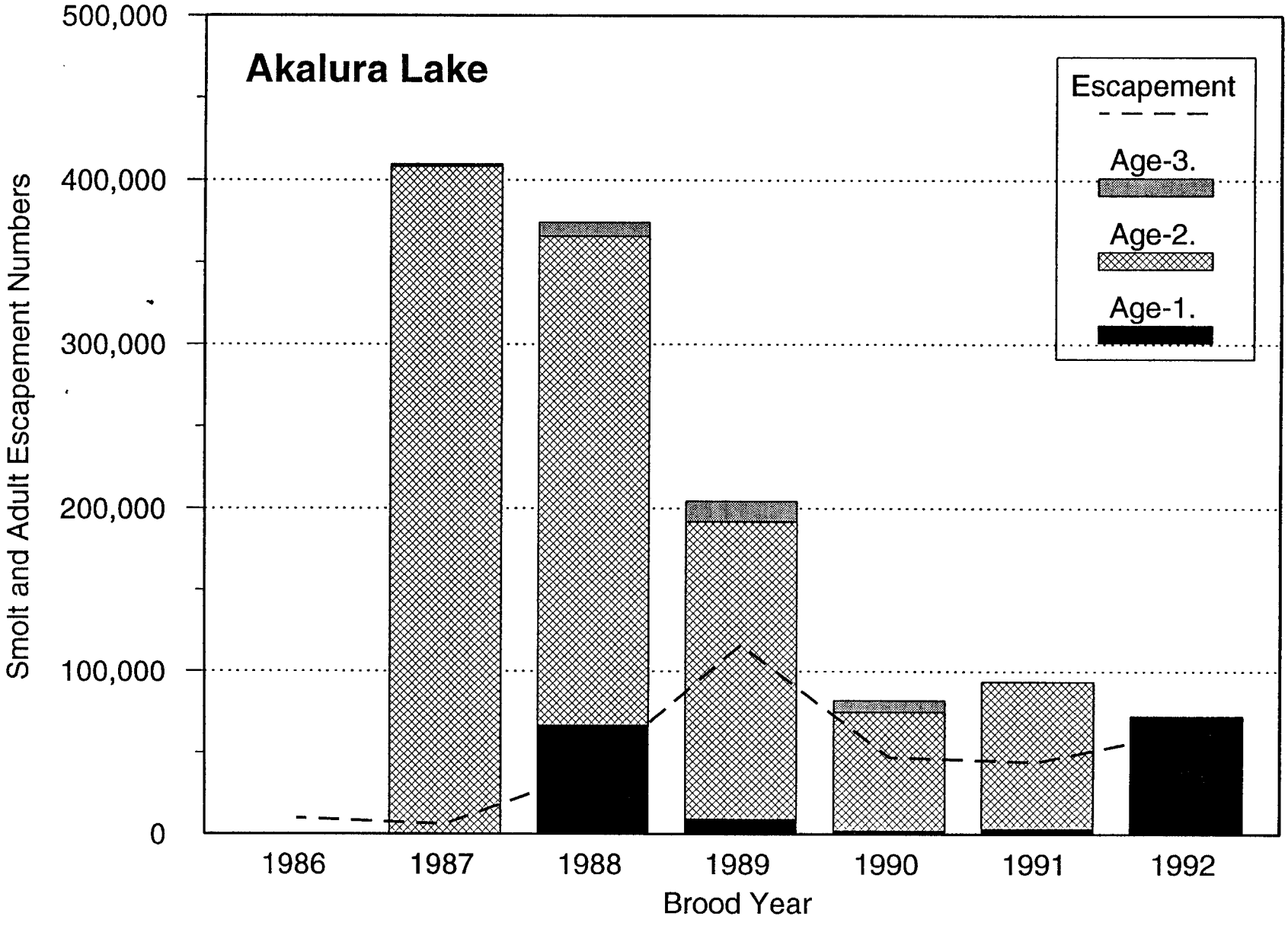

Figure 7. Sockeye salmon escapement and smolt production by age and brood year, Akalura Lake, 1986 - 1992.

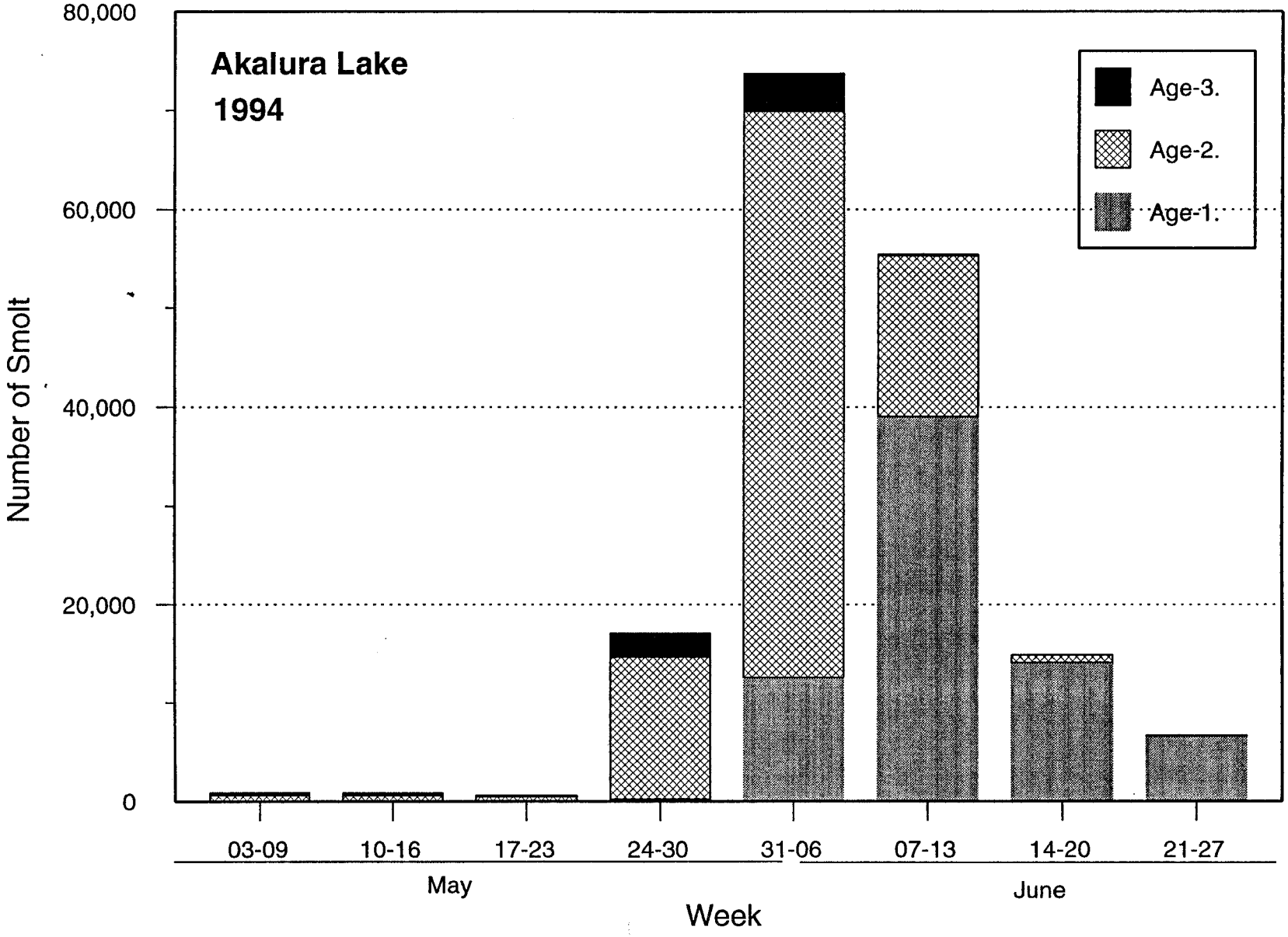

Figure 8. Sockeye salmon smolt outmigration timing by age, Akalura Lake, 1994.

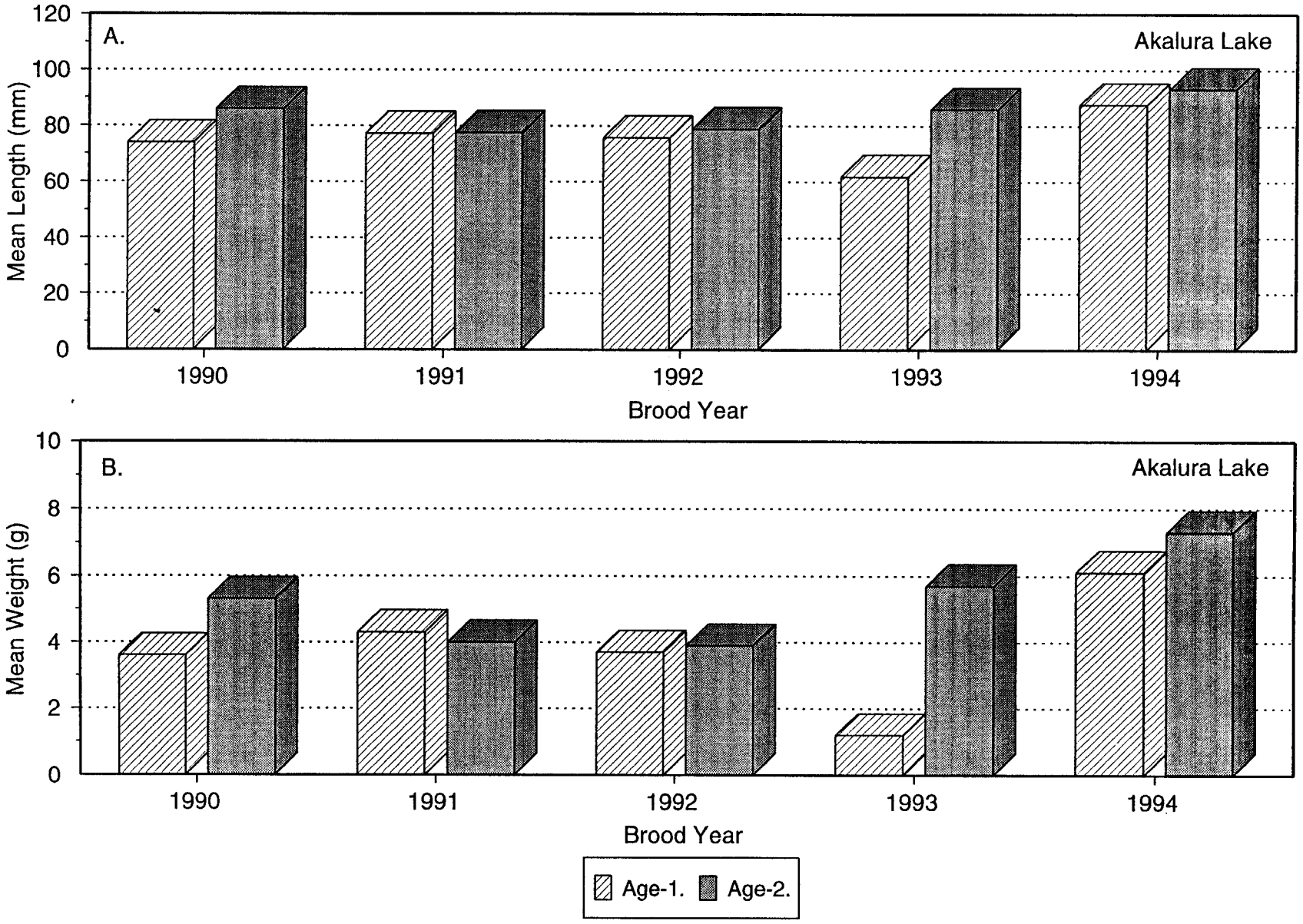

Figure 9. Akalura Lake mean smolt length (A) and weight (B) by year and age, 1990-1994.

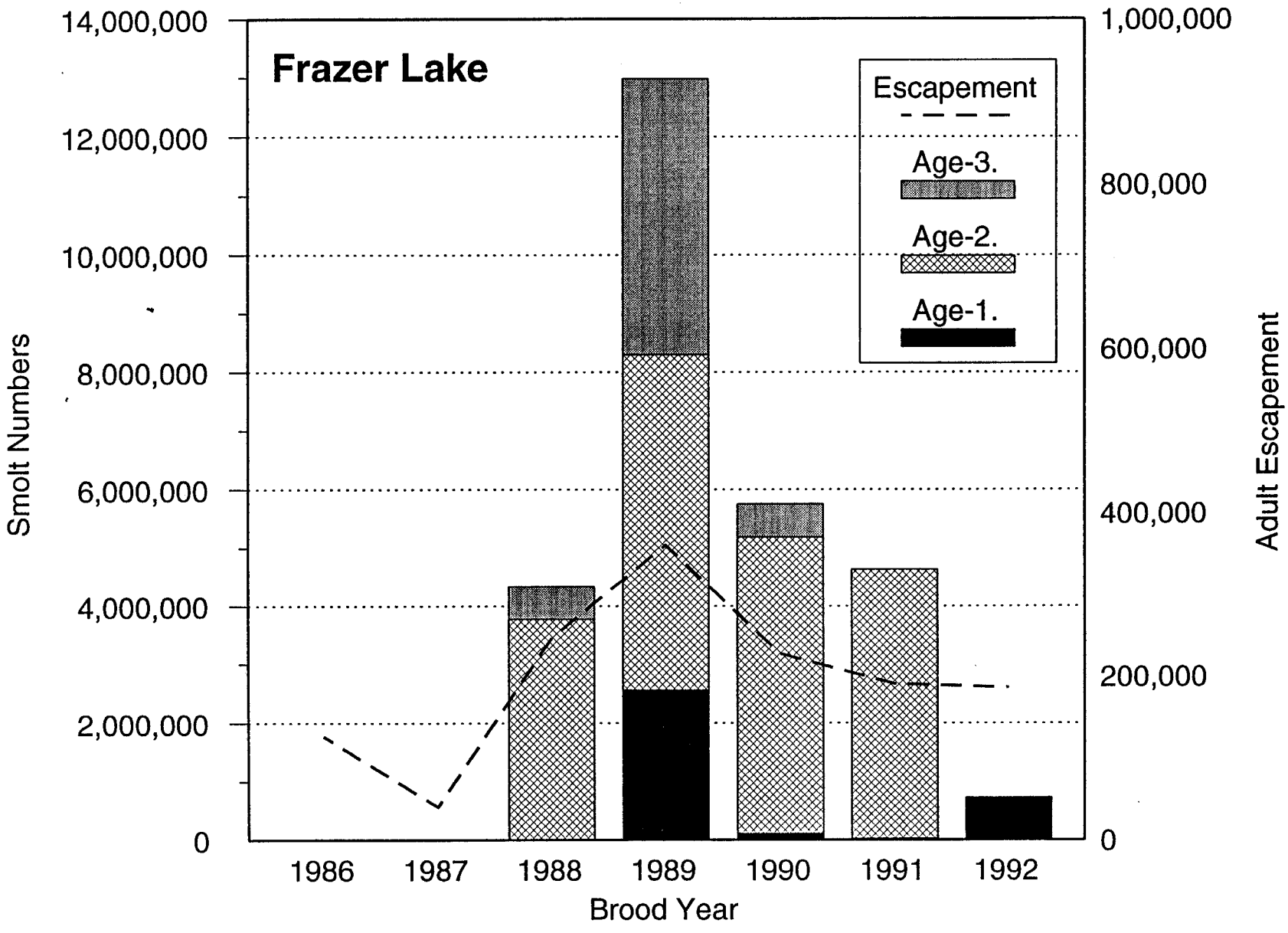

Figure 10. Sockeye salmon escapement and smolt production by age and brood year, Frazer Lake, 1986 - 1992.

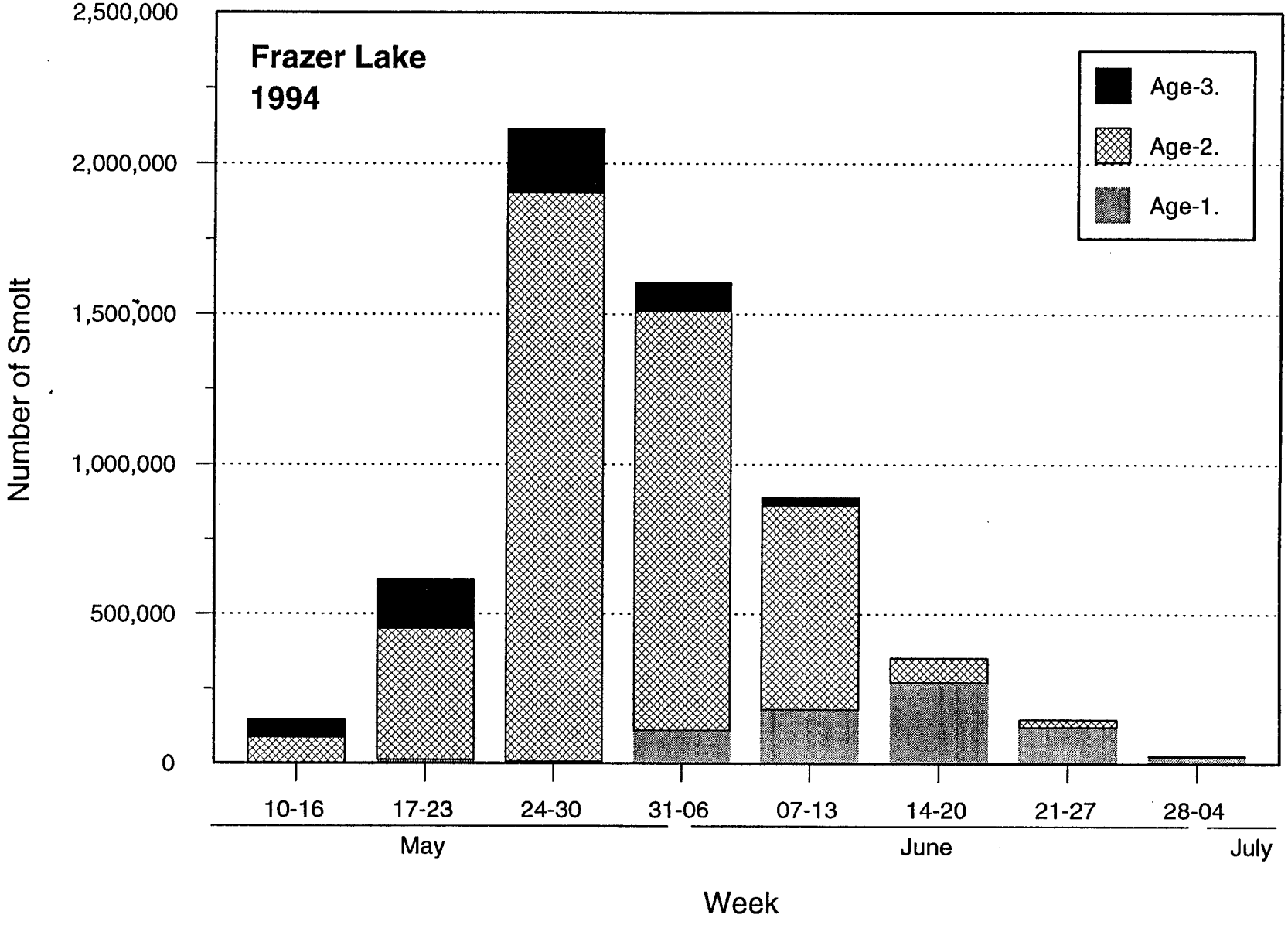

Figure 11. Sockeye salmon smolt outmigration timing by age, Frazer Lake, 1994.

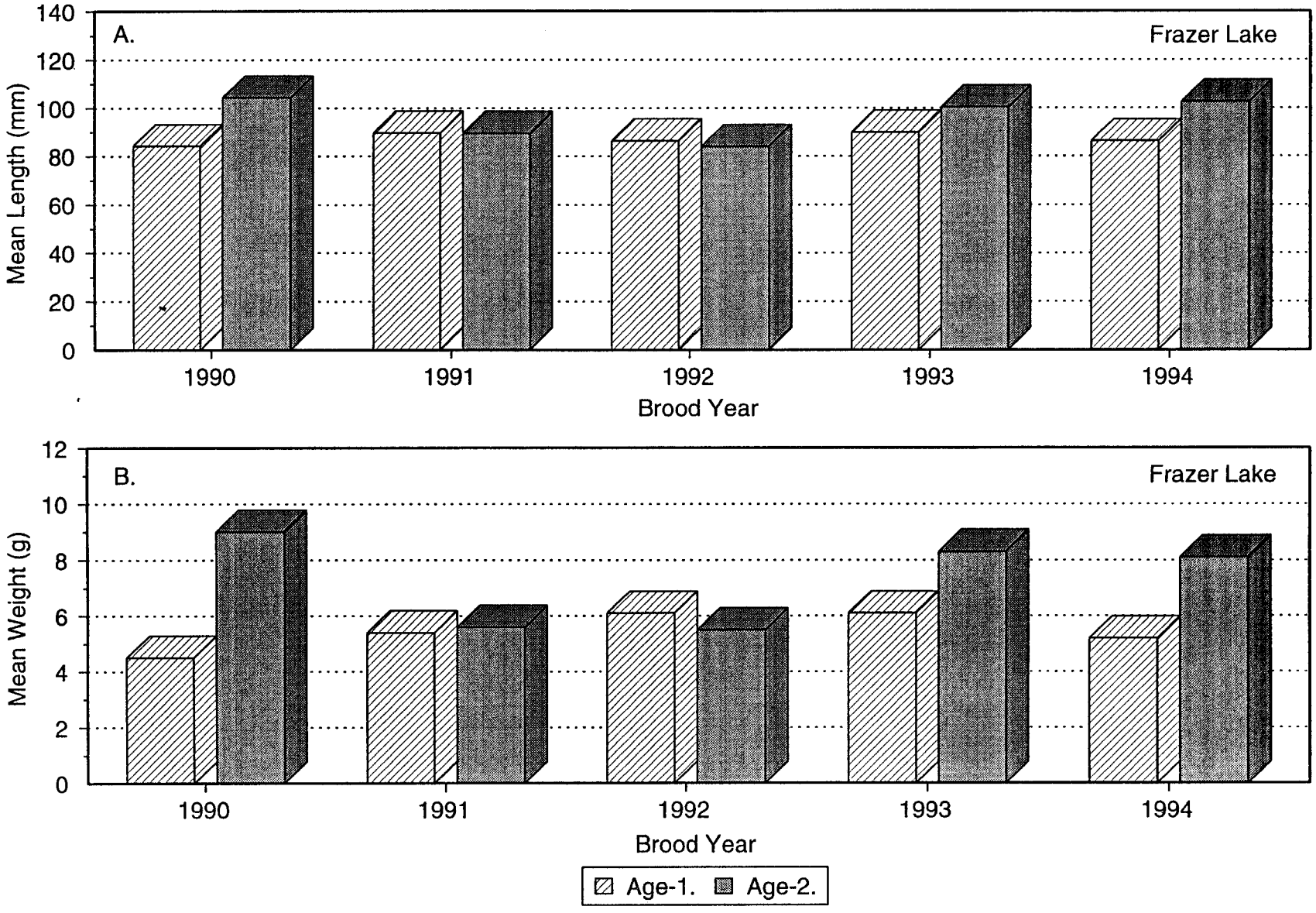

Figure 12. Frazer Lake mean smolt length (A) and weight (B) by year and age, 1990 through 1994.

APPENDIX

Appendix A.1. Red Lake sockeye salmon smolt trap catch and trap efficiency estimates, 1994.

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate %[d]
01-May							
02-May							
03-May							
04-May	0	0					
05-May	0	0					
06-May	0	0					
07-May	4	4					
08-May	13	17					
09-May	5	22					
10-May	3	25					
11-May	6	31					
12-May	7	38					
13-May	2	40					
14-May	40	80					
15-May	52	132					
16-May	188	320					
17-May	213	533					
18-May	51	584	441	98	47		
19-May	56	640		58	2		
20-May	85	725		85	1	50	11.3%
21-May	84	809					
22-May	85	894					
23-May	186	1,080					
24-May	892	1,972					
25-May	1,341	3,313	617	1,437	96		
26-May	5,985	9,298		6,006	21		
27-May	3,593	12,891		3,594	1	118	19.1%
28-May	8,494	21,385					
29-May	232	21,617					
30-May	8,281	29,898					
31-May	8,725	38,623					
01-Jun	5,435	44,058	631	5,519	84		
02-Jun	19,528	63,586		19,578	50		
03-Jun	3,025	66,611		3,029	4	138	21.9%
04-Jun	5,159	71,770					
05-Jun	3,495	75,265					
06-Jun	3,870	79,135					
07-Jun	2,257	81,392					
08-Jun	3,665	85,057	519	3,754	97		
09-Jun	1,111	86,168		1,127	26		
10-Jun	5,543	91,711		5,545	4	127	24.5%
11-Jun	3,442	95,153					
12-Jun	715	95,868					
13-Jun	2,080	97,948					
14-Jun	4,852	102,800					
15-Jun	3,202	106,002	523	3,262	63		
16-Jun	2,838	108,840		2,897	57		
17-Jun	2,856	111,696		2,870	14	134	25.6%
18-Jun	4,230	115,926					
19-Jun	1,237	117,163					
20-Jun	912	118,075					
21-Jun	1141	119,216					
22-Jun	1217	120,433	546	1,318	104		
23-Jun	218	120,651		220	2		
24-Jun	434	121,085		434	0	106	19.4%

-Continued-

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Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate %[d]
25-Jun	432	121,517					
26-Jun	568	122,085					
27-Jun	522	122,607					
Total	122,607		3,277	60,831	673		20.5%

[a] Each date listed covers a 24-hour period extending from noon to noon and identifies the date of the first noon of the 24-hour period.

[b] Number of fish caught does not include mark recoveries from trap efficiency tests.

[c] Represents the sum of marked recoveries for the particular dye test period.

[d] Determined from the cumulative number of marked and recovered fish by test period.

Appendix A.2. Akalura Lake sockeye salmon smolt trap catch and trap efficiency estimates, 1994.

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate %[d]
01-May							
02-May							
03-May							
04-May	4	4					
05-May	2	6					
06-May	1	7					
07-May	18	25					
08-May	90	115					
09-May	26	141					
10-May	8	149					
11-May	66	215					
12-May	21	236					
13-May	4	240					
14-May	11	251					
15-May	9	260					
16-May	18	278					
17-May	13	291					
18-May	8	299					
19-May	14	313					
20-May	33	346					
21-May	11	357					
22-May	8	365					
23-May	10	375					
24-May	12	387					
25-May	8	395					
26-May	22	417					
27-May	55	472	22	53	2		
28-May	138	610	54	144	6		
29-May	639	1,249	138	659	20		
30-May	1847	3,096		1,853	6		
31-May	671	3,767		672	1	35	16.4%
01-Jun	2119	5,886					
02-Jun	2398	8,284	539	2,458	71		
03-Jun	2563	10,847		2,591	28		
04-Jun	2751	13,598		2,755	4	103	19.1%
05-Jun	1951	15,549					
06-Jun	1078	16,627					
07-Jun	2905	19,532					
08-Jun	1285	20,817					
09-Jun	1896	22,713	560	1,962	66		
10-Jun	1611	24,324		1,627	16		
11-Jun	596	24,920		606	10	92	16.4%
12-Jun	356	25,276					
13-Jun	407	25,683					
14-Jun	205	25,888					
15-Jun	346	26,234					
16-Jun	177	26,411	329	185	8		
17-Jun	85	26,496	175	91	6		
18-Jun	59	26,555		63	4		
19-Jun	110	26,665		112	2		
20-Jun	61	26,726		64	3		
21-Jun	122	26,848		128	6	29	5.8%
22-Jun	75	26,923					
23-Jun	96	27,019	74	96	0		
24-Jun	44	27,063	87	49	5		

-Continued-

Appendix A.2. (page 2 of 2)

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate %[d]
25-Jun	20	27,083	43	23	3		
26-Jun	16	27,099		20	4		
27-Jun	15	27,114		16	1	13	6.4%
28-Jun							
Total	26,726		2,021	16,227	272		13.4%

[a] Each date listed covers a 24-hour period extending from noon to noon and identifies the date of the first noon of the 24-hour period.

[b] Number of fish caught does not include mark recoveries from trap efficiency tests.

[c] Represents the sum of marked recoveries for the particular dye test period.

[d] Determined from the cumulative number of marked and recovered fish by test period.

Appendix A.3. Frazer Lake sockeye salmon smolt trap catch and trap efficiency estimates, 1994.

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate %[d]
01-May		0					
02-May		0					
03-May		0					
04-May		0					
05-May		0					
06-May		0					
07-May		0					
08-May		0					
09-May		0					
10-May	8	8					
11-May	259	267					
12-May	29	296					
13-May	194	490					
14-May	138	628					
15-May	1,318	1,946					
16-May	5,497	7,443	1,059	5,523	26		
17-May	4,280	11,723		4,288	8		
18-May	2,525	14,248		2,527	2	36	3.4%
19-May	8,806	23,054					
20-May	1,417	24,471					
21-May	5,988	30,459					
22-May	6,944	37,403	1,052	6,990	49		
23-May	1,527	38,930		1,538	11		
24-May	5,996	44,926		5,999	3		
25-May	10,240	55,166		10,242	2	65	6.2%
26-May	7,475	62,641					
27-May	6,197	68,838					
28-May	31,036	99,874					
29-May	42,753	142,627	1,080	41,623	44		
30-May	4,213	146,840		4,227	14		
31-May	3,153	149,993		3,155	2	60	5.6%
01-Jun	20,374	170,367					
02-Jun	36,920	207,287					
03-Jun	6,405	213,692					
04-Jun	6,043	219,735					
05-Jun	6,813	226,548	1,102	5,646	35		
06-Jun	2,195	228,743		2,215	20		
07-Jun	1,221	229,964		1,221	0	55	5.0%
08-Jun	4,007	233,971					
09-Jun	5,812	239,783					
10-Jun	6,230	246,013					
11-Jun	8,531	254,544					
12-Jun	11,624	266,168	1,100	10,852	39		
13-Jun	7,993	274,161		8,006	13		
14-Jun	6,835	280,996		6,837	2	54	4.9%
15-Jun	4,615	285,611					
16-Jun	2,862	288,473					
17-Jun	1,183	289,656					
18-Jun	1,682	291,338					
19-Jun	694	292,032	1,104	718	32		
20-Jun	185	292,217		207	22		
21-Jun	704	292,921		710	6		
22-Jun	1210	294,131		1,211	1	61	5.5%
23-Jun	1254	295,385					
24-Jun	2636	298,021					
25-Jun	406	298,427					

-Continued-

Appendix A.3. (page 2 of 2)

Trap Catch			Trap Efficiency Test				
Date[a]	Daily[b]	Cum.	Marked (Dyed)	Examined For Marks	Marked Recoveries	Total Recoveries for Dye Test Period[c]	Recovery Rate %[d]
26-Jun	117	298,544	325	129	14		
27-Jun	1196	299,740		1,200	4		
28-Jun	1420	301,160		1,420	0	18	5.5%
Total	301,160		6,822	126,484	349		5.1%

[a] Each date listed covers a 24-hour period extending from noon to noon and identifies the date of the first noon of the 24-hour period.

[b] Number of fish caught does not include mark recoveries from trap efficiency tests.

[c] Represents the sum of marked recoveries for the particular dye test period.

[d] Determined from the cumulative number of marked and recovered fish by test period.

Appendix B.1. Red Lake daily sockeye salmon smolt population estimates, 1994.

Date	Population Estimate	95% CI Lower	95% CI Upper
04-May	0	0	0
05-May	0	0	0
06-May	0	0	0
07-May	36	2	70
08-May	117	51	183
09-May	45	7	83
10-May	27	2[a]	56
11-May	54	12	96
12-May	63	17	109
13-May	18	6[a]	41
14-May	359	221	497
15-May	467	299	634
16-May	1,688	1,201	2,175
17-May	1,912	1,367	2,457
18-May	458	293	623
19-May	503	325	680
20-May	763	516	1,010
21-May	661	457	866
22-May	596	419	773
23-May	1,176	884	1,467
24-May	5,132	4,061	6,202
25-May	7,060	5,873	8,247
26-May	31,509	26,381	36,637
27-May	18,916	15,818	22,014
28-May	43,460	36,527	50,392
29-May	1,155	932	1,378
30-May	40,113	33,922	46,304
31-May	41,167	34,917	47,416
01-Jun	24,992	21,281	28,703
02-Jun	89,797	76,582	103,011
03-Jun	13,910	11,824	15,996
04-Jun	23,168	19,775	26,561
05-Jun	15,337	13,108	17,565
06-Jun	16,603	14,229	18,977
07-Jun	9,471	8,118	10,825
08-Jun	15,067	12,764	17,369
09-Jun	4,567	3,843	5,292
10-Jun	22,787	19,324	26,250
11-Jun	14,017	11,885	16,149
12-Jun	2,885	2,419	3,350
13-Jun	8,314	7,050	9,579
14-Jun	19,217	16,361	22,073
15-Jun	12,567	10,704	14,429
16-Jun	11,138	9,483	12,793
17-Jun	11,209	9,543	12,874
18-Jun	17,454	14,796	20,112
19-Jun	5,381	4,505	6,256
20-Jun	4,194	3,479	4,909
21-Jun	5,566	4,595	6,537
22-Jun	6,316	5,199	7,433
23-Jun	1,131	897	1,365
24-Jun	2,253	1,826	2,679
25-Jun	2,242	1,818	2,667
26-Jun	2,948	2,403	3,493
27-Jun	2,709	2,205	3,213
	562,689	472,305	647,655

[a] Negative numbers.

Appendix B.2. Akalura Lake daily sockeye salmon smolt population estimates, 1994.

Date	Population Estimates	95% CI Lower	95% CI Upper
04-May	25	2	48
05-May	13	3[a]	28
06-May	6	5	17
07-May	113	55	170
08-May	563	367	760
09-May	163	89	237
10-May	50	16	84
11-May	413	262	564
12-May	131	68	195
13-May	25	2	48
14-May	69	27	111
15-May	56	19	93
16-May	113	55	170
17-May	81	35	128
18-May	50	16	84
19-May	88	39	136
20-May	207	119	294
21-May	69	27	111
22-May	50	16	84
23-May	63	23	102
24-May	75	31	119
25-May	50	16	84
26-May	138	72	203
27-May	344	214	475
28-May	864	578	1,150
29-May	4,000	2,785	5,216
30-May	11,563	8,109	15,017
31-May	4,201	2,926	5,476
01-Jun	12,209	8,730	15,688
02-Jun	12,647	10,421	14,873
03-Jun	13,518	11,142	15,894
04-Jun	14,509	11,962	17,056
05-Jun	10,590	8,686	12,494
06-Jun	6,027	4,904	7,150
07-Jun	16,744	13,653	19,836
08-Jun	7,643	6,179	9,108
09-Jun	11,646	9,438	13,853
10-Jun	9,895	8,012	11,779
11-Jun	3,661	2,933	4,389
12-Jun	2,511	1,954	3,068
13-Jun	3,371	2,572	4,169
14-Jun	2,056	1,492	2,620
15-Jun	4,396	3,113	5,680
16-Jun	3,051	2,077	4,024
17-Jun	1,465	951	1,979
18-Jun	1,017	635	1,399
19-Jun	1,896	1,256	2,535
20-Jun	1,051	659	1,443
21-Jun	2,103	1,403	2,802
22-Jun	1,293	829	1,756
23-Jun	1,655	1,085	2,224
24-Jun	758	454	1,062
25-Jun	345	171	519
26-Jun	276	125	426
27-Jun	259	114	403
	170,172	130,910	209,433

[a] Negative numbers.

Appendix B.3. Frazer Lake sockeye salmon smolt population estimates 1994.

Date	Population Estimate	95% CI Lower	95% CI Upper
10-May	157	50	264
11-May	5,077	4,284	5,869
12-May	568	359	778
13-May	3,802	3,154	4,451
14-May	2,705	2,187	3,223
15-May	25,833	22,872	28,794
16-May	107,744	96,419	119,068
17-May	83,890	74,998	92,782
18-May	49,491	44,110	54,873
19-May	172,601	154,665	190,538
20-May	27,774	24,614	30,934
21-May	117,367	105,062	129,673
22-May	136,105	121,889	150,322
23-May	29,930	26,549	33,311
24-May	117,524	105,202	129,846
25-May	200,708	179,906	221,510
26-May	146,513	131,236	161,790
27-May	121,464	108,740	134,187
28-May	608,319	545,971	670,666
29-May	837,977	752,222	923,732
30-May	82,577	73,819	91,334
31-May	61,800	55,162	68,438
01-Jun	399,339	358,291	440,387
02-Jun	723,648	649,545	797,750
03-Jun	125,541	112,402	138,680
04-Jun	118,445	106,030	130,861
05-Jun	133,538	119,583	147,492
06-Jun	43,023	38,302	47,744
07-Jun	23,932	21,166	26,698
08-Jun	78,539	70,193	86,885
09-Jun	113,918	101,964	125,872
10-Jun	122,111	109,321	134,900
11-Jun	167,211	149,824	184,599
12-Jun	227,835	204,268	251,402
13-Jun	156,666	140,354	172,979
14-Jun	133,969	119,970	147,967
15-Jun	90,456	80,894	100,017
16-Jun	56,096	50,040	62,152
17-Jun	23,187	20,498	25,877
18-Jun	32,968	29,276	36,660
19-Jun	13,603	11,903	15,302
20-Jun	3,626	2,998	4,254
21-Jun	13,799	12,079	15,519
22-Jun	23,717	20,973	26,460
23-Jun	24,579	21,747	27,411
24-Jun	51,667	46,063	57,270
25-Jun	7,958	6,852	9,064
26-Jun	2,293	1,827	2,760
27-Jun	23,442	20,727	26,158
28-Jun	27,833	24,666	30,999
	5,902,863	5,285,225	6,520,501

Appendix C.1. Red Lake sockeye salmon smolt emigration by age class, 1994.

Dates	Population Estimate	Ages 1.	2.	3.
5/07-5/09/94	197	0	197	0
5/10-5/16/94	2,675	45	2,629	0
5/17-5/23/94	6,068	103	5,862	103
5/24-5/30/94	147,343	884	146,017	442
5/31-6/06/94	224,973	11,249	212,374	1,350
6/07-6/13/94	77,107	7,402	69,705	0
6/14-6/20/94	81,159	10,226	70,933	0
6/21-6/27/94	23,165	10,494	12,671	0
Total	562,689	40,404	520,391	1,895

Appendix C.2. Akalura Lake sockeye salmon smolt emigration by age class, 1994.

Dates	Population Estimate	Ages 0.	1.	2.	3.
5/03-5/09/94	882	0	7	583	292
5/10-5/16/94	858	0	13	567	278
5/17-5/23/94	607	0	13	457	137
5/24-5/30/94	17,034	0	221	14,377	2,436
5/31-6/06/94	73,700	0	12,529	57,339	3,832
6/07-6/13/94	55,470	0	39,051	16,253	166
6/14-6/20/94	14,931	90	14,065	776	0
6/21-6/27/94	6,687	0	6,573	114	0
Total	170,172	90	72,474	90,467	7,141

Appendix C.3. Frazer Lake sockeye salmon smolt emigration by age class, 1994.

Dates	Population Estimate	Ages 1.	2.	3.
5/10-5/16/94	145,886	875	85,197	59,813
5/17-5/23/94	617,158	11,726	439,417	166,016
5/24-5/30/94	2,115,082	6,345	1,895,113	213,623
5/31-6/06/94	1,605,333	110,768	1,398,245	96,320
6/07-6/13/94	890,212	181,603	680,122	28,487
6/14-6/20/94	353,905	271,445	80,336	2,123
6/21-6/27/94	147,454	121,944	25,067	442
6/28-7/04/94	27,833	23,073	4,759	0
Total	5,902,863	727,781	4,608,258	566,825

Appendix D.1. Red Lake sockeye salmon smolt length, weight, and condition factor of samples collected, by age, and week, 1994.

		Length (mm)			Weight (g)			Condition Factor (K)		
Age	Week	N	Mean	SE	N	Mean	SE	N	Mean	SE
1	20	1	82.0		1	4.3		1	0.78	
1	21	4	80.3	5.5	4	3.9	0.8	4	0.70	0.05
1	22	2	71.5	18.5	2	3.7	2.1	2	0.90	0.11
1	23	17	82.9	2.0	17	4.8	0.3	17	0.82	0.03
1	24	33	86.7	1.1	33	5.3	0.2	33	0.80	0.02
1	25	43	88.9	1.1	43	5.6	0.2	43	0.78	0.01
1	26	125	86.0	0.6	125	5.0	0.1	125	0.78	0.01
Totals		225	86.2	0.5	225	5.1	0.1	225	0.79	0.01
2	19	22	95.5	1.9	22	6.7	0.4	22	0.75	0.02
2	20	56	99.7	0.9	56	7.6	0.2	56	0.76	0.01
2	21	234	99.6	0.4	234	7.3	0.1	234	0.73	0.00
2	22	325	104.9	0.4	324	8.9	0.1	324	0.78	0.00
2	23	322	98.2	0.4	322	7.4	0.1	322	0.77	0.00
2	24	312	96.2	0.3	312	7.3	0.1	312	0.81	0.00
2	25	296	96.6	0.3	296	7.2	0.1	296	0.80	0.00
2	26	151	94.1	0.5	151	6.8	0.1	151	0.81	0.01
Totals		1,718	98.7	0.2	1,717	7.6	4E-2	1,717	0.78	0.00
3	21	4	107.8	2.5	4	9.8	0.9	4	0.78	0.02
3	22	1	104.0		1	7.9		1	0.70	
3	23	2	99.5	5.5	2	8.0	0.9	2	0.81	0.04
Totals		7	104.9	2.3	7	9.0	0.6	7	0.78	0.02

Appendix D.2. Akalura Lake sockeye salmon smolt length, weight and condition factor from samples collected, by age, and week, 1994.

		Length (mm)			Weight (g)			Condition Factor (K)		
Age	Week	N	Mean	SE	N	Mean	SE	N	Mean	SE
0	25	2	73.0	3.0	2	3.4	0.3	2	0.87	0.03
Totals		2	73.0	3.0	2	3.4	0.3	2	0.87	0.03
1	19	1	73.0		1	2.9		1	0.75	
1	20	2	77.5	6.5	2	3.7	0.8	2	0.77	0.01
1	21	2	90.0	3.0	2	6.6	0.5	2	0.90	0.01
1	22	2	89.0	4.0	2	6.3	0.9	2	0.89	0.01
1	23	59	89.4	0.7	59	6.5	0.1	59	0.91	0.00
1	24	245	87.3	0.3	245	6.0	0.1	245	0.90	0.00
1	25	292	87.1	0.3	292	6.1	0.1	292	0.91	0.00
1	26	118	87.9	0.4	118	6.3	0.1	118	0.92	0.00
Totals		721	87.5	0.2	721	6.1	4E-2	721	0.91	0.00
2	19	80	86.4	0.5	80	5.4	0.1	80	0.82	0.01
2	20	90	87.4	0.5	90	5.5	0.1	90	0.81	0.00
2	21	67	90.7	0.6	67	6.5	0.1	67	0.86	0.01
2	22	135	96.5	0.4	135	8.4	0.1	135	0.93	0.00
2	23	271	95.4	0.3	271	8.1	0.1	271	0.92	0.00
2	24	102	94.1	0.5	102	7.6	0.1	102	0.90	0.00
2	25	16	92.9	1.8	16	7.5	0.5	16	0.92	0.01
2	26	2	96.0	4.0	2	7.4	1.0	2	0.83	0.01
Totals		763	93.1	0.2	763	7.3	0.1	763	0.89	0.00
3	19	40	91.4	1.0	40	6.4	0.2	40	0.83	0.01
3	20	44	93.4	0.9	44	6.7	0.2	44	0.82	0.01
3	21	20	95.7	1.7	20	7.6	0.4	20	0.86	0.01
3	22	23	102.2	0.8	23	9.9	0.2	23	0.93	0.01
3	23	18	103.4	1.5	18	10.5	0.5	18	0.94	0.01
3	24	1	102.0		1	9.2		1	0.87	
Totals		146	95.8	0.6	146	7.7	0.2	146	0.86	0.01

Appendix D.3. Frazer Lake sockeye salmon smolt length, weight, and condition factor of samples collected, by age, and week, 1994.

		Length (mm)			Weight (g)			Condition Factor (K)		
Age	Week	N	Mean	SE	N	Mean	SE	N	Mean	SE
1	20	2	96.0	10.0	2	6.4	1.6	2	0.71	0.04
1	21	6	78.2	1.4	6	3.7	0.3	6	0.78	0.06
1	22	1	92.0		1	5.3		1	0.68	
1	23	24	83.7	0.7	24	4.7	0.1	24	0.79	0.01
1	24	71	85.1	0.4	71	4.7	0.1	71	0.76	0.01
1	25	263	85.1	0.2	263	5.0	0.1	263	0.80	0.00
1	26	288	87.6	0.2	288	5.6	0.1	288	0.84	0.00
1	27	58	87.6	0.3	58	5.6	0.1	58	0.83	0.01
Totals		713	86.3	0.2	713	5.2	3E-2	713	0.81	0.00
2	19	13	108.7	1.0	13	9.3	0.3	13	0.72	0.01
2	20	184	104.8	0.3	184	8.5	0.1	184	0.74	0.00
2	21	228	104.0	0.3	228	8.3	0.1	228	0.73	0.00
2	22	312	102.6	0.2	312	8.0	0.1	312	0.74	0.00
2	23	305	102.1	0.2	305	8.1	0.1	305	0.75	0.00
2	24	266	101.5	0.3	266	7.8	0.1	266	0.75	0.00
2	25	78	100.0	0.7	78	8.0	0.3	78	0.78	0.01
2	26	58	101.7	1.0	58	8.6	0.3	58	0.80	0.00
2	27	12	97.6	2.3	12	7.6	0.5	12	0.81	0.02
Totals		1,456	102.6	0.1	1,456	8.1	3E-2	1,456	0.75	0.00
3	19	17	114.6	1.4	17	11.2	0.6	17	0.74	0.01
3	20	129	112.7	0.3	129	10.6	0.1	129	0.74	0.00
3	21	86	112.5	0.5	86	10.5	0.1	86	0.73	0.00
3	22	35	111.5	0.9	35	10.2	0.3	35	0.73	0.01
3	23	21	115.3	0.8	21	12.0	0.3	21	0.78	0.01
3	24	11	114.2	1.8	11	11.3	0.6	11	0.75	0.02
3	25	2	102.0	8.0	2	7.9	1.9	2	0.73	0.01
3	26	1	126.0		1	16.6		1	0.83	
Totals		302	112.8	0.3	302	10.7	0.1	302	0.74	0.00

Appendix E.1. Number of young-of-year (YOY) sockeye salmon captured by beach seining of standard littoral areas, Red Lake, 1992-1994.

	1992					1993					1994				
	Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
08-May	0	0	0	0	0										
09-May											2	0	0	4	6
10-May															
11-May															
12-May															
13-May						39	3	215	0	257					
14-May															
15-May	0	0	0	0	0										
16-May											10	5	23	2	40
17-May															
18-May															
19-May															
20-May						10	26	1	58	95					
21-May	2	47	1	0	50										
22-May															
23-May											250	16	6	0	272
24-May															
25-May															
26-May															
27-May						21	0	15	27	63					
28-May															
29-May															
30-May	16	1	0	26	43						252	2	1	56	311
31-May						171	1	4	8	184					
01-Jun															
02-Jun															
03-Jun															
04-Jun															
05-Jun	2	0	0	15	17										
06-Jun											116	2	5	3	126
07-Jun															
08-Jun						93	3	2	3	101					
09-Jun															
10-Jun															
11-Jun															
12-Jun															
13-Jun	23	2	0	3	28						241	1	1	7	250
14-Jun						44	7	10	16	77					
15-Jun															
16-Jun															
17-Jun															
18-Jun															
19-Jun	53	20	0	6	79										
20-Jun											43	20	0	7	70
21-Jun						4	8	5	1	18					
22-Jun															
23-Jun															
24-Jun															
25-Jun															
26-Jun															
27-Jun	39	8	5	14	66						21	18	2	3	44
28-Jun															

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	1992					1993					1994				
	Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
29-Jun															
30-Jun						52	21	18	1	92					
01-Jul															
02-Jul															
03-Jul															
04-Jul	106	6	1	5	118										
05-Jul															
06-Jul															
07-Jul															
08-Jul															
09-Jul															
10-Jul	73	2	20	8	103										
11-Jul															
12-Jul															
13-Jul															
14-Jul															
15-Jul															
16-Jul															
17-Jul	27	2	8	14	51										
18-Jul															
19-Jul															
20-Jul															
21-Jul															
22-Jul															
23-Jul															
24-Jul	24	4	31	[a]	59										

[a] Did not sample due to beach spawning sockeye

Appendix E.2. Number of stickleback captured by beach seining standard littoral areas, Red Lake, 1992-1994.

	1992					1993					1994				
	Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
08-May	0	0	0	78	78										
09-May											1	1		1	3
10-May															
11-May															
12-May															
13-May						174	20	86	10	290					
14-May															
15-May	1	2	0	0	3										
16-May											5	12			17
17-May															
18-May															
19-May															
20-May						1,916	139	1,172	2,600	5,827					
21-May	1,078	408	26	279	1,791										
22-May															
23-May											214	26	7		247
24-May															
25-May															
26-May															
27-May						1,840	0	617	443	2,900					
28-May															
29-May															
30-May	1,091	9	0	502	1,602						157	16	8	588	769
31-May						5,535	608	59	415	6,617					
01-Jun															
02-Jun															
03-Jun															
04-Jun															
05-Jun	357	34	1	744	1,136										
06-Jun											78	88	17	520	703
07-Jun															
08-Jun						736	882	147	513	2,278					
09-Jun															
10-Jun															
11-Jun															
12-Jun															
13-Jun	685	124	0	58	867						679	71	36	24	810
14-Jun						876	661	156	171	1,864					
15-Jun															
16-Jun															
17-Jun															
18-Jun															
19-Jun	1,685	805	0	24	2,514										
20-Jun											154	1,126	11	9	1,300
21-Jun						10,000[a]	424	126	49	10,599					
22-Jun															
23-Jun															
24-Jun															
25-Jun															
26-Jun															
27-Jun	68	178	2	56	304	7,396	38	54	49	7,537	152	188	95	9	444

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	1992					1993					1994				
	Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
28-Jun															
29-Jun															
30-Jun															
01-Jul															
02-Jul															
03-Jul															
04-Jul	785	192	1	56	1,034										
05-Jul															
06-Jul															
07-Jul															
08-Jul															
09-Jul															
10-Jul	432	250	1	83	766										
11-Jul															
12-Jul															
13-Jul															
14-Jul															
15-Jul															
16-Jul															
17-Jul	894	12	1	768	95	1,878									
18-Jul															
19-Jul															
20-Jul															
21-Jul															
22-Jul															
23-Jul															
24-Jul	553	501	1,025[a]		[b] 2,079										

[a] Estimated due to heavy algae.
[b] Did not sample due to beach spawning sockeye.

Appendix E.3. Average lengths of young-of-year (YOY) sockeye salmon captured by beach seining standard littoral areas, Red Lake, 1992-1994.

	1992					1993					1994				
	Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
08-May															
09-May											31			32	31
10-May															
11-May															
12-May															
13-May						32	33	31		32					
14-May															
15-May															
16-May											34	31	33	32	32
17-May															
18-May															
19-May															
20-May						30	32	31	34	33					
21-May	33	35	35		35										
22-May															
23-May											33	32	33		33
24-May															
25-May															
26-May															
27-May						34		32	35	34					
28-May															
29-May															
30-May	35	30		35	35	35		36	36	35	33	34	33	33	33
31-May															
01-Jun															
02-Jun															
03-Jun															
04-Jun															
05-Jun	32			33	33										
06-Jun											34	34	34	34	34
07-Jun															
08-Jun						36	36	34	36	36					
09-Jun															
10-Jun															
11-Jun															
12-Jun															
13-Jun	34	37		36	34						34	34	32	34	33
14-Jun						35	38	35	35	35					
15-Jun															
16-Jun															
17-Jun															
18-Jun															
19-Jun	34	40		34	36										
20-Jun											34	40		34	36
21-Jun						36	39	35	32	37					
22-Jun															
23-Jun															
24-Jun															
25-Jun															
26-Jun															
27-Jun	34	39	32	34	35						40	37	39	46	40
28-Jun															

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Appendix E.3. (page 2 of 2)

	1992					1993					1994				
	Site No.					Site No.					Site No.				
Date	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
29-Jun															
30-Jun						38	41	33	36	37					
01-Jul															
02-Jul															
03-Jul															
04-Jul	36	38	30	34	36										
05-Jul															
06-Jul															
07-Jul															
08-Jul															
09-Jul															
10-Jul	34	36	32	37	34										
11-Jul															
12-Jul															
13-Jul															
14-Jul															
15-Jul															
16-Jul															
17-Jul	31	42	36	38	34										
18-Jul															
19-Jul															
20-Jul															
21-Jul															
22-Jul															
23-Jul															
24-Jul	40	48		39	40										

Appendix F.1. Tow net survey catches from Red Lake, 1990-1994.

Year	Tow		Catch by Species					
			Sockeye			Stickleback		
	No.	Min.	No.	%	CPUE	No.	%	CPUE
1990	1	30	7	1.9	0.2	370	98.1	12.3
	2	30	3	0.6	0.1	569	99.4	19.1
	3	30	10	1.9	0.3	513	98.1	17.4
Total		90	20	1.4	0.2	1,452	98.6	16.1
1991	1	30	56	10.9	1.8	457	89.1	15.2
	2	30	22	3.6	0.7	593	96.4	19.8
	3	30	13	5.4	0.4	227	94.6	7.6
Total		90	91	6.7	1.0	1,277	93.3	14.2
1992	1	30	10	3.2	0.3	304	96.8	10.1
	2	32	30	3.0	0.9	968	97.0	30.2
	3	30	22	1.1	0.7	1,918	98.9	63.9
Total		92	62	1.9	0.7	3,190	98.1	34.7
1993	1	20	21	17.5	1.1	99	82.5	4.9
	2	21	7	9.2	0.3	69	90.8	3.3
	3	21	13	4.8	0.7	257	95.2	12.2
Total		62	41	8.8	0.7	425	91.2	6.8
1994	1	20	32	6.5	1.6	462	93.5	23.1
	2	20	31	3.5	1.6	859	96.5	42.9
	3	20	23	3.8	1.2	588	96.2	29.4
Total		60	86	4.3	1.4	1,909	95.7	31.8

Appendix F.2. Tow net survey catches from Akalura Lake, 1990-1991.

Year	Tow		Catch by Species					
			Sockeye			Stickleback		
	No.	Min.	No.	%	CPUE	No.	%	CPUE
1990	1	30	114	4.3	3.8	2,545	95.7	84.8
	2	20	57	6.1	2.8	874	93.9	43.7
	3	20	66	7.3	3.3	833	92.7	41.6
Total		70	237	5.3	3.4	4,252	94.7	60.7
1991	1	25	74	4.0	3.0	1,807	96.0	72.3
	2	20	24	1.6	1.2	1,466	98.4	73.3
	3	25	49	0.6	2.0	7,492	99.4	299.7
Total		70	147	1.3	2.1	10,765	98.7	153.8

Appendix F.3. Tow net survey catches from Frazer Lake, 1990-1994.

Year	Tow		Catch by Species					
			Sockeye			Stickleback		
	No.	Min.	No.	%	CPUE	No.	%	CPUE
1990	1	20	0	0.0	0	15	100.0	0.7
	2	20[a]						
	3	20	46	93.9	2.3	3	6.1	0.1
	4	20	60	81.0	3.0	14	19.0	0.7
Total		60	106	76.8	1.8	32	23.2	0.5
1991	1	20	117	79.6	5.8	30	20.4	1.5
	2	20	9	64.3	0.4	5	35.7	0.2
	3	20	48	68.6	2.4	22	31.4	1.1
Total		60	174	75.3	2.9	57	24.7	0.9
1992	1	30	123	49.6	4.1	125	50.4	4.2
	2	30	163	16.6	5.4	820	83.4	27.3
	3	30	42	7.1	1.4	551	92.9	18.4
Total		90	328	18.0	3.6	1,496	82.0	16.6
1993	1	20	3	2.7	0.1	106	97.3	5.3
	2	20	12	10.3	0.6	104	89.7	5.2
	3	20	1	3.4	0.0	28	96.6	1.4
Total		60	16	6.3	0.3	238	93.7	4.0
1994	1	20	01	0.0	0.0	506	100.0	25.3
	2[b]	20	0	0.0	0.0	0	0.0	0.0
	3	20	01	12.5	0.0	07	87.5	0.4
Total		60	02	0.4	0.0	513	99.6	8.5

[a] Townet survey for this transect not conducted due to severe weather.
[b] Results from this tow are suspect, however owing to severe weather a replicate tow was not conducted.

Appendix G.1. Daily climatological observations, water temperature, and water depth monitored at Red Lake field station, 1994.

Date	Time	Temperature Air(c)	Temperature Water(c)	Cloud Cover %	Wind Dir.	Wind Vel. (Mph)	Stream Gauge (1 cm)	Comments
03-May	1800	10	5	75	SE	10~15	25	Snow in am ~ 1" accum, 1500', vis. 10 mi
04-May	1800	14	5	100	SSE	10-15	24	
05-May	1800	9	7	100	SE	10	24	Intermittent rain
06-May	1800	8	6	100	SE	10-15	24	Intermittent rain
07-May	1800	9	6.5	100	SE	VAR	24	3000' solid, vis. 15 mi, intermittent rain/snow
08-May	1800	12	8.5	75	NE	15-20	24	Intermittant rain, vis. unlim.
09-May	1800	9	7	100	SE	0-5	24	3000' solid, vis. 10+ mi., light drizzle
10-May	1800	13	9	100	SE	10-15	25	High overcast, vis.15+ mi.
11-May	1800	14	8.5	50	NNE	10-15	25	3500' broken, vis. 10 mi. (haze)
12-May	1800	15	8	85	SE	15	24	3000' broken, vis. 5-10 mi., haze and fog
13-May	1800	12	7.5	100	NW	15	23	Light rain
14-May	1800	11	10	80	E	10	24	3000' broken, vis. 5 mi., heavy rain in am
15-May	1800	10.5	10.5	100	V - SE	0-5	24	High overcast with lower broken 3500', vis. 5 mi., light haze
16-May	1800	8	9	100	SE	25	24	Vis. <5mi. , rain/snow squalls
17-May	1800	14	11	100	V - NE	0-5	24	Vis. 10+ mi.
18-May	1800	6	10	100	SSE	15-20+	24	1500' ceiling, intermittent hard rain, vis. 3-5 mi.
19-May	1800	7.5	6	100	SSE	0-5+	23	2000' ceiling, lower fog, vis. 5 mi., intermittent rain
20-May	1800	14	9	99	ESE	5	23	High thin overcast
21-May	1800	17	8	80	E	5-10	23	3500' broken, vis. unlim., occasional showers
22-May	1800	12	8	75	NNE	25+ GUST	23	3500' broken, vis. 15 mi., haze
23-May	1800	9	5	100	NW	15	23	2000' ceiling, vis. 5 mi., intermittent rain (hard at times)
24-May	1800	8	7	100	W	0-10	23	1500' solid, lower fog, vis. 5 mi., light drizzle
25-May	1800	9	7	85	CALM	0	23	3500' broken, vis. unlim., clearing, occasional rain
26-May	1800	9	6.5	75	SE	15	22	4000' broken, vis. unlim., occasional rain squalls
27-May	1800	15	7	10	S	10-15	22	High broken, vis. unlim., water down ~ 1/2 cm, NO RAIN!
28-May	1800	17	9	60	WNW	15-20	22	4-5000', vis. unlim., no rain in ~ 40 hrs
29-May	1800	7	6	95	NW	25+	21	4-5000', vis. unlim., few smolt, rain squalls
30-May	1800	7	6.5	50	NW	10-15	21	4000' ceiling, vis. 10-20 mi.
31-May	1800	9	7.5	85	W	10-15	21	2-3000', vis. 5-10 mi., light rain
01-Jun	1800	15	8	5	W	15	21	CAVU
02-Jun	1800	12	7	50	NNE	15	21	Vis. unlim., heavy frost last night
03-Jun	1800	9	8	50	SE	5	21	Vis. unlim., heavy frost again last night
04-Jun	1800	11	8.5	100	VARIABLE	<5	21	Vis. unlim., 4000'+ ceiling
05-Jun	1800	18	8	40	SE	15-20	20	Vis. unlim., light rain last night, 5000'+ ceiling
06-Jun	1800	10	8	100	SE	10-15	21	Vis. 10 mi., haze, 4000' solid
07-Jun	1800	9	8	100	SE	15-20	20	2-3000' ceiling, vis. 5-10 mi.
08-Jun	1800	12	8.5	95	SE	5-10	20	4-5000' ceiling, vis. unlim., rain squalls
09-Jun	1800	11	10	75	W	5-10	20	3-4000' broken, vis. 10+ mi., occasional rain squalls
10-Jun	1800	11.5	10	100	W	10-15	20	2-3000' solid, 5-10 mi. vis., heavy rain squalls
11-Jun	1800	14	10	100	NNW	5-10	20	3000 solid, vis. 5-10 mi., rain/sleet squalls
12-Jun	1800	13.5	10	100	SSW	10-15	20	2-3000' solid, vis. 5-10 mi., rain squalls

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Appendix G.1. (page 2 of 2)

Date	Time	Temperature Air(c)	Temperature Water(c)	Cloud Cover %	Wind Dir.	Wind Vel. (Mph)	Stream Gauge (1 cm)	Comments
13-Jun	1800	14	10	100	W	5-10	19	2000 solid, vis. 5 mi.
14-Jun	1800	19	13.5	0	W	10-15	19	CAVU
15-Jun	1800	15	11	5	WNW	15-20	19	~ CAVU
16-Jun	1800	19	12	~5	W	5-10	18	~ CAVU, this am 2000' solid
17-Jun	1800	19	13	~5	W	15-20+	18	CAVU, few high thin clouds
18-Jun	1800	21	12	~5	W	5-10	18	CAVU, high thin overcast
19-Jun	1800	12	12	100	LIGHT & VAR	<5	18	1000' ceiling, vis. 2-3 mi., rain, drizzle, and fog all day
20-Jun	1800	14	11	100	SE	5	18.5	1000' solid, vis. 2-3 mi.
21-Jun	1800	12	11	100	SE	5	19.5	500-1000' solid, vis. 2-3 mi., rain heavy at times
22-Jun	1800	10	11	100	SE	5-10	20	1000-1500' solid, vis. 5+ mi.
23-Jun	1800	11	10	100	SE	10-15	20	1500' solid, vis. ~5 mi.
24-Jun	1800	10	10	99.9	WSW	10-15	20.5	2000' ceiling, vis. 5-10 mi., occasional heavy rain
25-Jun	1800	12	10	90	WSW	10-15	20	2500' broken, vis. 5-10 mi.
26-Jun	1800	12	10	90			20	
27-Jun	1800	14	12	50	NNW	10-15	20	4000' broken, vis. unlim.
28-Jun	1800	14	11.5	90	LIGHT & VAR	0-5	20	4000' slightly broken

Appendix G.2. Daily climatological observations, water temperature, and water depth monitored at Akalura field station, 1994.

Date	Time	Temperature		Cloud Cover	Wind		Stream Gauge	Comments
		Air(c)	Water(c)	%	Dir.	Vel. (Mph)	(1 cm)	
04-May	1800	9	6	100	SE	15	45	Ceiling 1000'; winds SW towards nightfall
05-May	1800	7	5	100	SE	20	45	Ceiling 1000'solid; rain by nightfall
06-May	1800	7	5	100	SW	20	48	Ceiling 1200' solid; rain
07-May	1800	6	5	100	SW	15	48	Ceiling 2200' solid; winds NW 20 by morning
08-May	1800	8	6	50	NW	25	45	Ceiling 2500' broken; partly sunny
09-May	1800	10	6	100	SW	<5	45	Ceiling 2000' solid
10-May	1800	11	7	95	SE	20	45	Ceiling 2000' slightly broken; winds calm by nightfall; drizzle
11-May	1800	13	8	60	NW	15	45	Ceiling 2500' broken; sunshine
12-May	1800	10	7	100	SW	25	43	Sunny most of day; calm winds and rain showers by evening; clear, calm, and cold by 2400
13-May	1800	11	8	60	W	5	43	Sunny, vis. unlim.; ceiling 3000'; by nightfall ceiling came down (fog), rain, calm winds
14-May	1800	10	7	100	SE	25	43	Rain all day; wind gusts >30
15-May	1800	10	7	100	SE	20	40	Ceiling 2000'
16-May	1800	9	7	100	SE	10	40	Ceiling 2000'; rain
17-May	1800	14	8	100	SW	5	40	Ceiling 2500'; by 0300 SE winds 20 and rain
18-May	1800	7	7	100	SE	25	43	Ceiling 1200'; with lower fog; rain (heavy at times); rain ended at 2000 hr
19-May	1800	8	7	100	SE	15	40	Ceiling 800' with lower fog, rain
20-May	1800	12	8	75	NE	15	40	Ceiling 2500'
21-May	1800	10	8	100	SE	25	40	Rain; ceiling 2500'; afternoon winds were SW 25, Slightly broken
22-May	1800	10	9	75	NW	10	40	Ceiling 3000'; rain by 2400 and SE winds 10
23-May	1800	9	8	100	SE	5	40	Ceiling 800'; rain (heavy at times); water depth stable but velocity up (1.5 m/sec)
24-May	1800	10	8	90	SE	15	41	Ceiling 3000'; frost by 0030
25-May	1800	10	9	80	NW	10	43	Ceiling 2500'
26-May	1800	10	8	100	E	15	41	Ceiling 2500'; stream gauge = 37.5cm by 0215 hrs
27-May	1800	12	10	50	W	15	36	CAVU; ceiling 3500-4000'
28-May	1800	15	11	75	NW	10	36	Vis. unlim.; ceiling >3500'
29-May	1800	11	11	90	NW	20	36	Ceiling 2500'
30-May	1800	12	10	70	NW	<5	35	Ceiling 3000'
31-May	1800	13	10	90	SW	15	36	Ceiling 3000'; rain from 1900-2100hr (heavy at times)
01-Jun	1800	15	12	5	NW	5	35	CAVU
02-Jun	1800	15	12	50	NW	10	35	Ceiling 2500'; vis. unlim.
03-Jun	1800	13	11	90	SE	<5	35	CAVU most of day; NW wind 10, wind switched at 1630 and ceiling came down (heavy rain)
04-Jun	1800	15	10	90	SW	<5	35	Ceiling 2500'
05-Jun	1800	10	10	80	S	25	35	Ceiling 2000'
06-Jun	1800	11	11	100	SE	15	34	Ceiling 2200'; winds SE >25 most of afternoon
07-Jun	1800	11	11	100	SE	<5	33	Ceiling 2000'; rain (drizzle)

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Appendix G.2. (page 2 of 2)

Date	Time	Temperature Air(c)	Temperature Water(c)	Cloud Cover %	Wind Dir.	Wind Vel. (Mph)	Stream Gauge (1 cm)	Comments
08-Jun	1800	11	11	90	SE	20	33	Ceiling 2500'
09-Jun	1800	13	12	60	SE	10	33	Ceiling 3000'; wind SW <5 by 1900hr
10-Jun	1800	14	12	100	N	5	33	Ceiling 2000'
11-Jun	1800	13	12	95	SW	<5	33	Ceiling 2200'
12-Jun	1800	16	12	100	SW	10	31	Ceiling 2500'; Rain, drizzle, and fog by 1900 with calm winds
13-Jun	1800	16	13	85	SW	5	31	Ceiling 1500'; winds North 25 by 1900hr
14-Jun	1800	18	16	5	NW	10	30	CAVU
15-Jun	1800	18	16	0	NW	15	30	CAVU
16-Jun	1800	15	14	25	NW	15	30	CAVU
17-Jun	1800	17	16	0	NW	20	30	CAVU
18-Jun	1800	18	17	0	NW	15	30	CAVU
19-Jun	1800	14	13	100	SW	5	31	Rain, Drizzle,Fog; vis.<1 mi.; rain all day; ceiling 200'
20-Jun	1800	15	14	100	SW	5	31	Rain, Drizzle, Fog; vis. 1 mi.; ceiling 200' with lower fog
21-Jun	1800	14	12	100	SW	20	43	RDF; ceiling 500' with lower fog; vis. <1 mi.; steady rainfall all day
22-Jun	1800	12	13	100	SW	10	36	Ceiling 1500'; drizzle; vis. 10 mi.
23-Jun	1800	14	13	100	SE	15	36	Ceiling 1500;; drizzle; vis. 5-10 mi.; heavy rain by 1945hr, wind increased to 25 and vis. <0.5 mi.
24-Jun	1800	10	12	100	W	15	35	Ceiling 2500'; vis. 10 mi.
25-Jun	1800	13	13	70	SW	20	35	Ceiling 3000'; vis. unlim.
26-Jun	1800	13	12	100	SE	15	35	Ceiling 2200'; vis. 5-10 mi.
27-Jun	1800	15	13	80	NW	15	35	Ceiling 3000'; vis. unlim.

Appendix G.3. Daily climatological observations, water temperature, and water depth monitored at Frazer Lake field station, 1994.

Date	Time	Temperature Air(c)	Temperature Water(c)	Cloud Cover %	Wind Dir.	Wind Vel. (Mph)	Stream Gauge (1 cm)	Comments
11-May	1800	16	6	70	S	<5	35	Mix of sun and clouds
12-May	1800	11	6	90	SE	20	37	Cloudy
13-May	1800	14	7	50	E	10	38	Cloudy
14-May	1800	9	6	100	E	25	38	Light rain all day
15-May	1800	11	6	100	E	20	38	Cloudy
16-May	1800	10	6	100	E	25	38	Cloudy, windy, and cold
17-May	1800	14	6	100	E	15	38	Cloudy and windy
18-May	1800	9	6	100	E	20	39	Cloudy, windy, and cold rain
19-May	1800	8	6	100	E	15	40	Cloudy, windy, light rain
20-May	1800	11	5	90	E	5	41	Cloudy
21-May	1800	11	5	100	E	20	41	Rain - just started
22-May	1800	15	6	100	E	5	43	Cloudy; light mist
23-May	1800	10	6	100	SE	10	43	Cloudy and rain
24-May	1800	11	5	100	E	5	44	Cloudy
25-May	1800	9	6	100	SE	10	44	Cloudy
26-May	1800	11	6	100	E	15	43	Cloudy
27-May	1800	17	6	30	SW	15	43	Partly cloudy
28-May	1800	15	7	20	W	15	43	Partly cloudy
29-May	1800	12	7	80	SW	20	42	Mostly cloudy
30-May	1800	13	7	100	W	5	42	Cloudy
31-May	1800	12	7	100	W	5	42	Cloudy
01-Jun	1800	15	8	0	SW	10	42	Clear
02-Jun	1800	12	8	65	NW	5	42	Cloudy
03-Jun	1800	12	9	100	NW	10	42	Rain
04-Jun	1800	11	8	50	E	<5	40	Partly cloudy
05-Jun	1800	13	7	100	E	20	40	Cloudy
06-Jun	1800	12	6	100	E	30	39	Cloudy
07-Jun	1800	13	6	100	E	10	39	Cloudy
08-Jun	1800	15	6	100	E	25	39	Cloudy
09-Jun	1800	16	6	90	E	5	39	Mostly cloudy
10-Jun	1800	12	9	100	NW	10	39	Showers
11-Jun	1800	12	9	100	E	10	39	Cloudy
12-Jun	1800	13	9	100	E	10	39	Rain
13-Jun	1800	15	10	25	W	17	40	Partly cloudy
14-Jun	1800	22	12	2	SW	16	40	Sunny
15-Jun	1800	19	13	0	W	18	40	Sunny
16-Jun	1800	16	11	0	W	20	40	CAVU
17-Jun	1800	18	13	0	NW	25	42	CAVU
18-Jun	1800	20	13	0	W	15	41	CAVU
19-Jun	1800	14	9	100	E	10	41	Rain
20-Jun	1800	15	9	100	SW	8	42	Cloudy
21-Jun	1800	12	8	100	W	8	43	Rain and showers
22-Jun	1800	14	8	100	W	5	44	Cloudy

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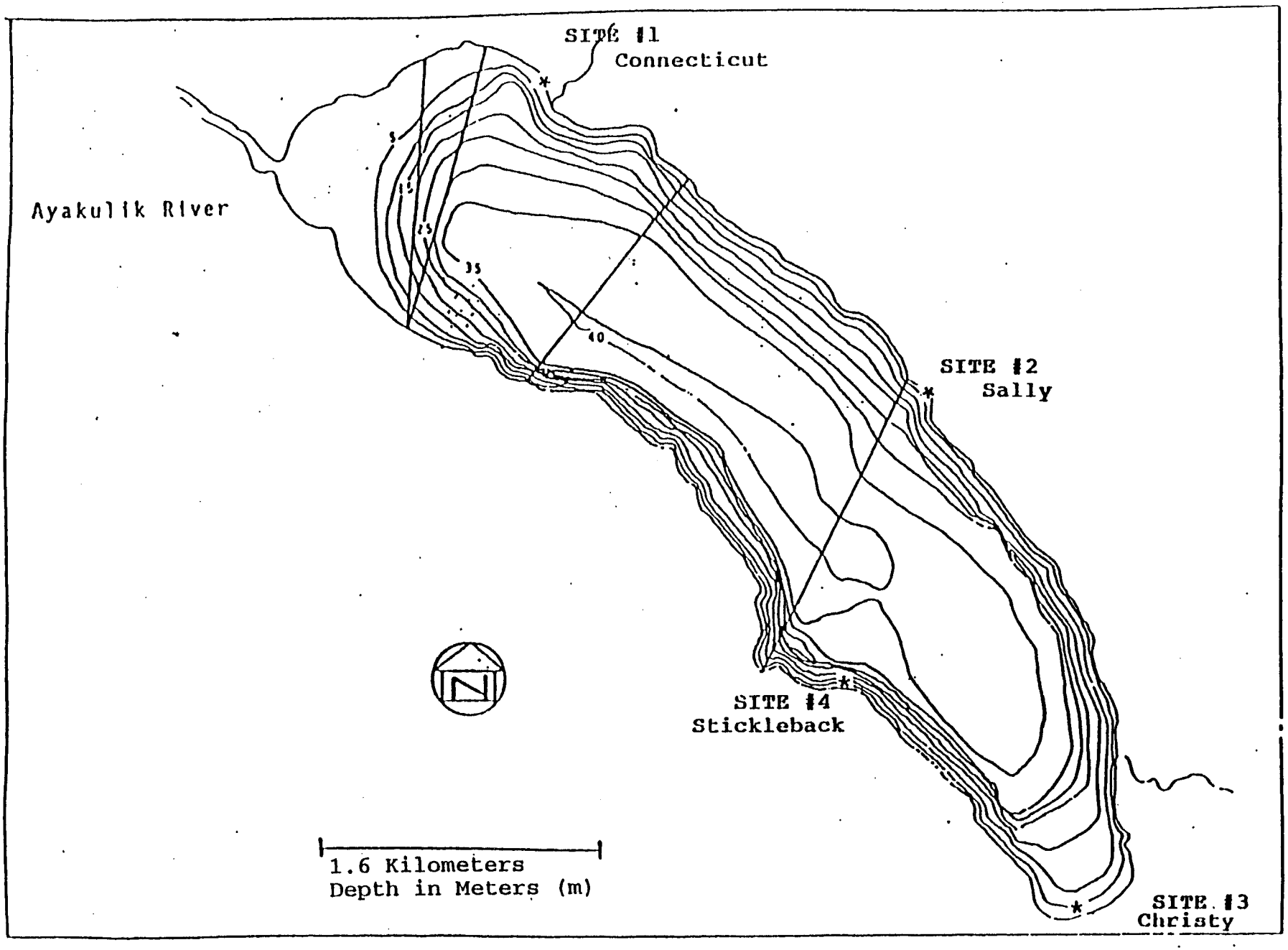
Appendix G.3. (page 2 of 2)

Date	Time	Temperature Air(c)	Temperature Water(c)	Cloud Cover %	Wind Dir.	Wind Vel. (Mph)	Stream Gauge (1 cm)	Comments
23-Jun	1800	13	9	100	SE	20	43	Cloudy
24-Jun	1800	11	9	100	W	15	44	Rain and showers
25-Jun	1800	10	9	90	NW	10	43	Showers
26-Jun	1800	11	10	100	SE	25	43	Rain
27-Jun	1800	14	10	80	N	10	44	Partly cloudy
28-Jun	1800	12	9	100	SE	10	43	Cloudy; showers
29-Jun	1800	15	13	0	NW	10		CAVU



Appendix H.1. Map of Red Lake with littoral zone seine sites identified.

Appendix I.1. Preliminary forecast of the Red River (Ayakulik River) sockeye salmon run, 1995.

Issue Date: 9/23/94

FORECAST AREA: **Kodiak, Ayakulik River (Red River)**

SPECIES: **Sockeye Salmon**

PRELIMINARY FORECAST OF THE 1995 RUN:

	Forecast Estimate (thousands)	Forecast Range (thousands)
Total Run Estimate	325	250-400
Escapement Goal	200-300	
Harvest Estimate	75	

FORECAST METHODS:

The 1995 Ayakulik sockeye run forecast represents the sum of six age specific estimates determined from sibling relationships and smolt indices. Age 1.3 fish were estimated from age 1.2 siblings, while the age 2.3 return from age 2.2 siblings. Ages 1.1, 1.2, 2.1, and 2.2 returns were estimated from brood year smolt numbers.

The forecast range is a subjective estimate of the 80% confidence interval.

FORECAST DISCUSSION:

The 1995 Ayakulik sockeye run is expected to be a 10-year record low, the product of unfavorable Red Lake rearing conditions from excessive brood year escapements. It can be expected that minimal, if any, commercial fishing time should occur within the Inner and Outer Ayakulik Sections of the SW Kodiak District. Poor Ayakulik runs should be expected for at least two more years. A recovery is expected in 1997 as preliminary data indicate a robust number of fry currently rearing in Red Lake. Another indicator is that food resources for the fry are good relative to zooplankton density, species composition, and size.

Although a portion of the 1995 run projection is derived from a limited smolt data set, our confidence in the forecast estimate is good.

If the 1995 run materializes as projected, 2-ocean age fish will comprise about 35% of the run and 3-ocean age fish 60%.

Error in the previous year (1994) forecast was less than 1%.

Prepared By: Bruce M. Barrett and Patricia A. Nelson
Regional Fishery Biologists
Commercial Fisheries Management and Development Division
Kodiak

Appendix I.2. Preliminary forecast of the Frazer Lake sockeye salmon run, 1995.

Issue Date: 10/07/94

FORECAST AREA: **Kodiak, Frazer Lake**

SPECIES: **Sockeye Salmon**

PRELIMINARY FORECAST OF THE 1995 RUN:

	Forecast Estimate (thousands)	Forecast Range (thousands)
Total Run Estimate	725	500-1,000
Escapement Goal	140-200	
Harvest Estimate	525	

FORECAST METHODS:

The 1995 Frazer Lake run forecast was derived from sibling relationships taken from recent brood year return (1979-91) and smolt (1990-94) data. The run forecast is the product of six individual age class estimates. Age 1.1 return was determined from 1994 age 1. smolt numbers; age 1.2 from 1993 age 1. smolt numbers, and age 2.2 from age 2.1 siblings. Age 2.3 was derived from age 2.2 siblings, and lastly the age 3. 2 return was estimated using the 1993 age 3. smolt outmigrant estimate and the relationship of 1991-93 age 2. and age 3. smolt to age .2 adult returns.

The forecast range is a subjective estimate of the 80% confidence interval.

FORECAST DISCUSSION:

The 1995 Frazer Lake run should be similar in magnitude to the 1994 run. Two-ocean age fish are expected to comprise about 70% of the run and 3-ocean age fish 30%. The dominant ages should be 2.2 (39%) and 3.2 (30%) fish.

The forecasted 1995 run of 725,000 fish is for the Alitak Bay District only. We assume that fishing time and intensity on the west side of Kodiak Island will be about the same as occurred in 1994. If this occurs, the Alitak Bay District catch should be about 525,000 sockeye salmon of Frazer Lake origin.

In the Alitak Bay District, the Frazer Lake run timing is from mid June to mid July; the peak is commonly in late June.

Our confidence in this forecast is fair, mainly because this is the first year we have forecasted an age 3.2 component. Typically, age 3.2 Frazer fish constitute less than 5% of a return. In 1993, an estimated 4.7 million age 3. smolt outmigrated which is about 9X more age 3 smolt than previously documented. For the 1995 run forecast, the estimated age 3.2 component is 215,000 fish or 30% of the total run. Note, however that the actual 1995 age 3.2 return could be much higher.

Error in the previous year (1994) forecast was 8%.

Prepared by: Bruce M. Barrett and Patricia A. Nelson
Regional Fishery Biologists
Commercial Fisheries Management and Development Division
Kodiak